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Developments in Information and Knowledge Management Systems for Business Applications

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Preface

Companies need sustainable solutions to the pressure to deal with high levels of risk and uncertainty. Many companies face this challenge and, therefore, must find new ways to deal with it. These solutions are often based on digital-influenced techniques. By highlighting ongoing progress in structural management, this volume of our subseries encourages further research regarding the subject. Previously understood knowledge, technologies and data can provide a huge assist with this goal.

In this monograph, we present a diverse range of research studies that cover various aspects of the modern world, including technology, business, language, and healthcare. The authors in this volume provide valuable insights into different topics, and their research findings offer significant contributions to their respective fields.

Chapter "A Case Study on Cloud Computing: Challenges, Opportunities, and Potentials," focuses on cloud computing and explores the challenges, opportunities, and potentials of this technology. Chapter "Are Code Review Smells and Metrics Useful in Pull Request-Level Software Defect Prediction?" investigates the usefulness of code review smells and metrics in pull request-level software defect prediction. In Chap. "User Reactions and Localization in the Video Game Industry: Developer and Publisher Dominances and Regional Release Date and Review Text Specifics," the authors examine user reactions and localization in the video game industry and discuss the dominances of developers and publishers, as well as regional release date and review text specifics.

Chapter "Lexical Norms in Business, Informal and Internet Communication" explores lexical norms in business, informal, and internet communication. Chapter ""Linguistic Images of Man and Woman in the Story of Ivan Franko "Cross-Paths": Attributive Compatibility" delves into the linguistic images of man and woman in the story of Ivan Franko, "Cross-Paths," and discusses attributive compatibility. Chapter "New Anglicisms in the Ukrainian Language: Social Internet Communication Context" examines new anglicisms in the Ukrainian language in the social internet communication context.

Chapter "Dynamic and Distributed Service Discovery Based Management System for City Parking Statistics Data Collection from Mobile Scanner Vehicles" presents a dynamic and distributed service discovery-based management system for city

parking statistics data collection from mobile scanner vehicles. Chapter "Information Management Processes: Review of the State Open Data Web Portal" provides a review of the state open data web portal and the information management processes. Chapter "Investment Evaluation Methods for Business Performance" investigates investment evaluation methods for business performance.

In Chap. "Organization and Financing of Healthcare in the Slovak Republic and Selected European Countries", the authors explore the organization and financing of healthcare in the Slovak Republic and selected European countries. Chapter "Legislation on the Distribution of Financial Services in Selected EU Member States and the Innovative Way of Financial Intermediation in the Slovak Republic" discusses legislation on the distribution of financial services in selected EU member states and the innovative way of financial intermediation in the Slovak Republic. Chapter "A Comparison of the Strategies of SMEs and Large Companies in the Field of Occupational Safety" compares the strategies of SMEs and large companies in the field of occupational safety.

Chapter "Digital Supply Chain Implementation in the Food Industry: An Interpretive Structural Modeling Approach" presents an interpretive structural modeling approach to the digital supply chain implementation in the food industry. Chapter "Analysis of the Introduction of Electronic Services in Public Administration: World Experience" analyzes the introduction of electronic services in public administration worldwide. Chapter "Development of a Web Application for Electronic Banking" focuses on the development of a web application for electronic banking.

Chapter "Risk Analysis of Supply Chain Quality Management in Food Industry" explores the risk analysis of supply chain quality management in the food industry. Chapter "Resilience of Home Health Care Providers in the Digital Era: A Scoping Review" presents a scoping review of the resilience of home health care providers in the digital era. Chapter "Management Information System of the Critical Path of Construction Projects by Way of Example Berlin Brandenburg Airport (BER)" discusses the management information system of the critical path of construction projects using the Berlin Brandenburg Airport as an example.

Chapter "Creating Cross-Platform Application in Java and C++" presents the development of a cross-platform application in Java and C++. Chapter "Challenges and Perspectives of the Legislative Solution to the Problem of the Plots of Land of Unidentified Owners in the Slovak Republic—Defining the Public Interest" discusses the challenges and perspectives of the legislative solution to the problem of the plots of land of unidentified owners in the Slovak Republic. Chapter "The Evolution of the Service Sector: Aspects in the e-Services Development and Management" examines the evolution of the service sector and aspects of e-services development and management.

Chapter "Digital Transformation of SMEs During the COVID-19 Pandemic" explores the digital transformation of SMEs during the COVID-19 pandemic. Chapter "Artificial Intelligence in Human Resource Management: Personnel Marketing and Recruiting" examines the use of artificial intelligence in human resource management, particularly in personnel marketing and recruiting. Finally,

Chap. "The Impact IT Sector in the Structure of the Economy" presents the impact of the IT sector on the structure of the economy.

This monograph offers a comprehensive view of the latest developments in different fields, including technology, business, language, and healthcare. The authors' contributions provide valuable insights and shed light on various aspects of modern life, making this volume a must-read for researchers and practitioners in these areas.

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November, 2022

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A Case Study on Cloud Computing: Challenges, Opportunities, and Potentials

Lumbardha Hasimi and Daniel Penzel

Abstract This chapter concentrates on cloud computing challenges, possibilities and potentials analyzed from customer's point of view. The research implications of this work are focused on analyzing the implemented enterprise value of cloud computing and the obstacles and challenges towards developing its full potential. There are undoubtedly many ways businesses benefit from cloud computing services, with efficient real-time access to any information, free from traditional restrictions and limitations. Enterprises use cloud computing differently and have various intentions to integrate it. For many, the transition path was long, diverse, and with many effects and outcomes in the overall business scope. The case study presents the cloud computing journey of three enterprises that adopted and developed cloud computing at early stages, becoming outrider enterprises with valuable cloud structures.

Keywords Cloud computing services · Cloud customer · Cloud market

1 Introduction

For many businesses, deciding whether to operate a private, public, or hybrid cloud has been a significant topic of discussion [1, 2]. Due to pricing, startups and small- to medium-sized businesses typically integrate public cloud solutions, whereas major corporations and international players typically integrate private clouds due to security considerations. The majority of businesses are hesitant to move crucial apps to a public cloud but are open to the idea. Although, public clouds have higher use rates than private clouds [2, 3]. Although the cloud has shown growth probably faster than the enterprise IT market, the investment enterprises were ready to spend on the cloud remained short. According to Gartner, Inc., the worldwide end-user spending

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on the public cloud was forecasted to be 23.1% higher in 2021. The public cloud is expected to account for 51% of IT investment in the markets for application software, infrastructure software, business process services, and system infrastructure by 2025 [4]. In 2014, according to the report of RightScale, enterprise governance was lagging in comparison to cloud development. According to this study, as business cloud maturity increases, security worries about the technology lessen, while performance, cost control, and continuing compliance issues receive more emphasis. Today, this has shifted to another lagging risk management lags in changing cloudscape. As the cloud model evolves and enterprises shift toward a heavier reliance on cloud services, the enterprise risk management process does not change comparably [5]. One challenge the enterprises would want to decrease is cloud security, which users tend to see as progress along with the provider's experience.

While cloud services are constantly evolving, cloud computing is now way more potent than it was in its beginnings in terms of markets and services. The challenges regarding availability, geographical reach, and business continuity are decreasing, while the stand-out argument remains "a cost-effective way of IT services."

The commercial value of the cloud depends on a number of factors, including perks like operational costs being deducted from capital expenditures, service subscriptions, users paying for results rather than for equipment, and the "pay-as-you-go" model [6, 7].

Cloud users faced issues with no standard contracts between the parties for quite some time. There were aims for a standardized cloud strategy that would include terms, standards, and implementation procurement requirements and a European Cloud Partnership to enable interoperability. The Cloud Select Industry group was established to impose standards and develop solutions in certification, service level agreements, and code of conduct, even if this did not occur [8]. Recently, the approval of the EU Cloud Code of Conduct has been confirmed, which encompasses all cloud service layers and allows cloud service providers to demonstrate GDPR compliance [9].

Despite the security and strategic issues, cloud computing generates corporate and enterprise use. The provider segment is under the most pressure from consumers who frequently incorporate private or hybrid clouds. Because they stand out by offering extra services and support, niche suppliers might have a big influence here. The relationship between the customer and the provider should encourage niche players since they are able to provide consumers better, more useful, and more effective cloud solutions by using their superior cloud expertise. Through a deeper grasp of the cloud, customers with particular structures might make use of it and gain a competitive advantage.

The corporate use casts serious doubt on the notion that cloud computing has realized all of its promise.

1.1 Cloud Computing from Customer's Perspective

Cloud computing, developed as a new evolution in hosting, continues to be an essential target for organizations interested in scalability and cost-efficiency. Although the last years have shown the significant expansion of the cloud, there is still unexploited potential for its development. With the increase in the benefits of cloud computing, the percentage of cloud-deployed workloads has increased respectively. Flexera Report 2022 [10] reported on the latest progress and the rise of the importance of the cloud against cloud goals for all organizations. The outcomes are displayed in Fig. 1.

Most categories evolved, and the best benefit is focused on cost efficiency and savings, delivery speed, and increased speed of innovation. Another focus that has been long considered an important issue is the maturity of the cloud. After almost a decade of this crucial issue, the whole potential of the cloud as a mature system is still in process.

The data presented in Fig. 2 [1, 2], shows that the top concern of enterprises in 2022 [10] remains data security, followed by lack of resources/expertise and managing cloud spending. Although the increase in cloud-deployed enterprises has shown an explosive increase last few years, understanding the differences in cloud offerings is a dominant issue to consider. Hence, cloud segmentation is essential and often complex since it involves other disciplines such as managerial decisions, market theory, microeconomics, etc. [11]. Some expected shifts in the cloud are new types of applications and broader awareness and aspects of multi-cloud, edge computing,

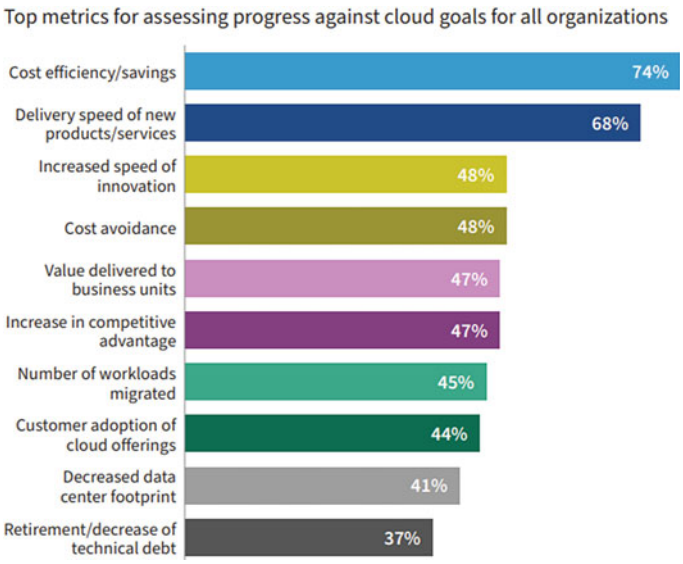

Fig. 1 Top metrics for assessing against goals for all organization [1, 2]

Fig. 2 Cloud computing top challenges for organizations according to Flexera report [1, 2]

greener cloud, serverless options, AI, and IoT concepts. A significant change and awareness of cloud integration bring it into the frontline of business and IT [12].

Although many had constituted a positive cloud development [13–15], the number of entities going cloud in the last two years proved that the predictions and projections, especially regarding the security and safety issues, had not stopped the increasing deployment. The fact is that security remains the primary concern. However, the necessity of the solutions brought by cloud structures has not stopped its growth. The acceptability and "sanity" of the public cloud were questioned in a report by BITKOM in 2015 [16], which specifically mentioned its immaturity. Private clouds were explicitly said to be the only superior option to take into consideration as long as businesses lack complete confidence in the security and data safety of the cloud.

This essay aims to show how useful cloud computing is for businesses. An essential idea in determining the value of cloud computing from an enterprise perspective is a proposal from an economic point of view. In cases of wrongly forecasted demand, appears a variability from the potential demand, which in return has a direct impact on the resources, causing waste and over-provision. Alternatively, the other worst case having it under-provisioned leads to missed opportunities. Therefore, adopting a solution that thoroughly matches supply with demand saves money and resources [17].

Figure 3 depicts several cost-related situations in an effort to highlight the advantages of transferring workloads to the public cloud. The anticipated demand for IT infrastructure components is shown by the gray line. The blue line depicts the strategy, which is typically a drawn-out procedure, for making recurring purchases to satisfy demand. The variation in demand projections, which results in resource

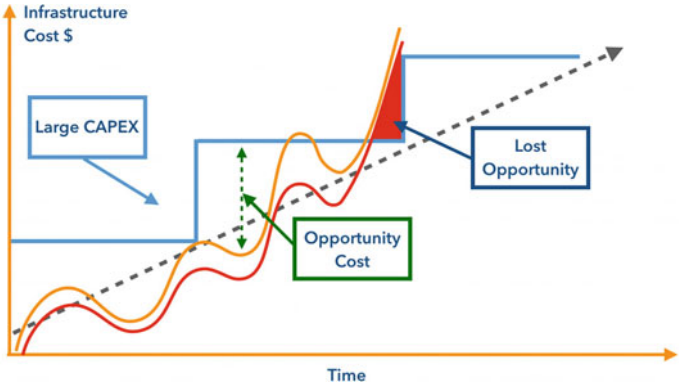

Fig. 3 Infrastructure cost versus time [17]

over-provision and waste, is depicted in green as an opportunity cost. The red-hued box above shows the under-provisioned and squandered opportunity. The flexibility of the public cloud allows for the avoidance of such issues [17].

2 Enterprise Value of Cloud Computing—The Concept of Value Creation

2.1 Target Audience

Every market sector is being targeted by several vendors. Providers strive to draw in as many customers as they can. They believe that, if provided properly, cloud computing is a service appropriate for every business. The portfolio of cloud service providers' clients shows the same outcome. Every consumer category is represented in the cloud-providing case study, depending on the focus of the cloud provider. The acceptability of cloud computing by a wide range of consumers grew quickly.

The cloud was once thought to be a service that mostly drew small and medium-sized businesses and startups as clients. Later, this was changed to reflect that most businesses who use the cloud for short-term projects look for "R&D initiatives, low-priority business applications, and web-based collaboration systems" [18]. However, it is true that for SMEs, cloud benefits like cost savings, virtualization, and office space preservation have shown to be a wonderful answer to resource and budgetary constraints [19]. Initial findings, however, have changed since then, and the cloud is now a framework for any object. The justification for cloud computing investments has also altered. Investment in hardware, software, and processing power has progressively increased [20, 21].

2.2 A Cloud-Based Business Model's Requirements

Cloud computing needs to develop even though it opens up a lot of opportunities. Providers create their models or position themselves in accordance with market conditions. In order for potential cloud adopters to reap further benefits for their structures, a cloud business model must tie together their claims. Some businesses' cloud business models must specify their services, state their requirements, locate and use cloud services that meet those needs, compose services as needed, and keep track of their outsourced services-based business activities [8].

Integration of services is the issue. As corporate structures change, the value of services rises, but so does their cost. It is feasible to integrate a cloud computing business model into a well-defined organization, but this requires extensive preparation and, for optimal security, an infrastructure for an internal private cloud. Through the use of the cloud, everyone may use IT at a minimal cost with maximum capability [22] Private clouds are not fully functioning since they are made to meet the demands of an organization and have issues with interoperability or service customisation. As a result, cloud service providers need to understand the many types of customers they serve in order to design a standard model that best suits those clients' requirements. A public or hybrid approach would be ideal. While specialized firms function by obtaining a service-oriented cloud business model, global players drive toward a standardized cloud infrastructure.

Depending on the business and kind of cloud computing, cloud computing offers a value proposition through cheaper costs, scalability, outsourcing of services, and a number of other options. A pay-per-use model or service-level agreements specify the earning rationale. Value networks are a problem when the cloud computing business model is taken into account. Although external organizations are frequently excluded from cloud computing architecture due to security threats and sensitive data, the provider and the customer are cooperative partners [23]. A solution to the issue of external integration would be necessary for a more advanced cloud computing approach. That problem is already the subject of hybrid clouds. The following problem arises while developing a more lucrative cloud-based business model due to resources and capabilities. Cloud computing has the potential to influence capabilities and optimize resource utilization. The development of cloud-based business models is hampered by issues with system compatibility and issues with the migration of particular applications. Making the switch to the cloud is a strategic step, particularly for start-ups and small- to medium-sized businesses [24].

A working business model may be created using the typical elements appropriate for cloud computing use, which center on non-sensitive data, services not impacted by latency or bandwidth, services with a normal resource pattern, and innovative applications [6]. Reusability, substitutability, extensibility, scalability, customization, composability, dependability, availability, and security are essential components of a cloud business model [25, 26].

Different business models fit for various consumer groups were described in [27]. According to them, the orientation determines how a cloud business model is implemented. A public cloud is provided via a service provider-oriented paradigm, which the provider creates and manages according to his preferences. Support and service agreements provide consumers the option to create a private, customer-focused solution that meets their needs. Enterprises may retain their data in-house with the help of internal private clouds, which increases security and reduces the danger of assaults on important data. The service provider and internal private models are combined in the All-In-One Enterprise Model. Both models have certain regions of overlap. The system's maturity, which results in trust in cloud computing, is a key prerequisite for a company to realize the full potential of a cloud-based business model.

An important factor in the adoption of cloud services is customer demands. By expanding and developing new consumer value propositions, businesses are using the cloud to create new income streams [28]. To foster trust and a connection with customers and adopt a specific business model, customers must be individually incorporated into the design of their cloud computing structure. The business model must adapt to the challenges of the business environment, expenses must be reduced, and the consumer must be able to see how the model creates value, including the definition of benefits. The correct corporate culture must be created for cloud computing from the perspective of the client [29]. For the outcome, the business model conversion is crucial.

2.3 Drivers of Enterprise Value Creation

When discussing the production of corporate value, cloud computing offers two viewpoints. First, there are the inherent qualities of cloud computing, which, if well defined, may help the organization's structure and development. Secondly, the incorporation of cloud computing has advantages and benefits. DaSilva and co. [30] "A breakthrough in how people and businesses operate and communicate over the Internet" is cloud computing. The first portion of the quotation already motivates businesses to provide value. The way that businesses use cloud computing has evolved. The second section is a vision focused on communication, one of the most important potential future drivers of corporate value in cloud computing. Businesses now have more ways to link services, collaborate with clients or other businesses, and impose collaboration, workload, and communication [31, 32]. To build a comprehensive framework for the organization that is best tied to strategy, capabilities, and structure, the reasons for embracing cloud computing must be merged.

Characteristics. The ability of features to generate enterprise value and the means through which they can do so are examined in this section. The section goes beyond just listing tangible benefits to explain the enterprise value that the IT sector expects. The expectations that business decisions have for cloud computing must be included.

The expectations of the IT sector on the service potential of cloud computing are shown in Table 1.

Table 1 Cloud contribution: cloud features

On-demand self service	A certain service is made available to the consumer without their involvement. The service system's automatic procedures run smoothly, and resources are employed right away. A uniform interface reduces the need for services. When services change over time, on-demand self-service plays a role
Elasticity/Flexibility	Elasticity is the capacity to adjust resource scaling as necessary. For consumers whose demand fluctuates and has seasonal peaks, elasticity offers opportunities. Elasticity has benefits even when demand is not precisely specified. The loss of service time can be avoided. Cloud service providers provide a pay-as-you-go option through elasticity, allowing clients to get their services at the cheapest price while transferring risk to the provider. Self-organization gives suppliers a lot of freedom. Customers gain from quick adjustments without server downtime. Possibilities can also be had with immediate access to hardware resources
Resource pooling	By combining resources, it is possible to increase flexibility and save costs, which can benefit customers. Unused resources may be made available to clients with more extensive demands. A consumer can access additional structures owned by other customers if his use increases
Measured service	Customers may only pay for what they use thanks to the pay-as-you-go concept. A service can be measured in a variety of ways, including in terms of time, bandwidth, and data. One of the most important integration criteria for cloud customers is cost-effectiveness. Start-ups and businesses in particular put their concentrate on it
Broad network access	Cloud computing is aided by improvements in internet availability and speed in some areas, which connects businesses globally. With any device included into the enterprise architecture, the user establishes a connection to a defined service platform
Scalability	Numerous consumers may be served simultaneously by a virtualized service. Scalability significantly reduces maintenance costs and accelerates the time it takes for new versions to reach the market. Rapid increases or decreases in computer power may be easily managed
Location independence	Cost efficiency is made possible by the immediate availability and reduced upfront expenditures. Customers do not have to put up the effort, resources, or time necessary to build their own data center
Sustainability	In order to decrease carbon emissions, brown energy or traditional grid electricity derived from fossil fuels are replaced with renewable energy sources to power cloud data centers
Multi-tenancy	Infrastructure is shared by customers. Customers don't have to worry about upgrades, maintenance, the underlying hardware, or installation issues, and the pre-configured service is easier to manage because it just uses one data center. The consumer benefits from the provider's cost savings as a result of its effective resource management

(continued)

Table 1 (continued)

Commitment	Large expenditures can be made in a data center, yet a cloud computing provider can be switched. It is possible to discontinue services without spending any further resources

Table 2 presents the benefits and advantages, the IT industry wants to achieve for its customers, through cloud computing services.

Adopting the cloud has a far greater scope than just the offered services from a provider. The fast-shifting marketplace makes it a critical value for the business and impacts expenses, resource expansion, and edge over competitors [6]. At the utility level, the advantages of cloud computing include not only cost advantages, power, hardware utilization, and software structures. Furthermore, the cloud brings value and fundamental shifts in better understanding the system and the overall business process. This contributes to improving business processes while creating an ecosystem that enables a value chain in the innovative business model.

2.4 Businesses with Exceptional Cloud Computing Infrastructure

The cloud computing architectures of three pioneering businesses that adopted and developed cloud computing are examined in this section. Businesses utilize cloud computing in different ways and have varied integration goals. The case study will highlight how advanced those companies' cloud computing options are and how much of the anticipated benefit of cloud computing has already been realized.

In Table 3 (a), three outrider companies that have already created useful cloud architectures are analyzed. Three tables that provide several areas of relevance are used to organize the analysis.

Table 3 (b) presents an overview of the strategy, vision, and expectations of the outrider enterprises.

Table 3 (c) deals with the benefits the outriders achieved. A categorization of the levels of value is presented. The business model and the future agenda shall provide a look into the operations of the outriders.

Table 2 Cloud computing benefits and advantages for enterprises

Costs	The use of cloud networks is higher, and there are considerable cost savings [33]. Low total cost of ownership is implemented through the cloud computing technology. The primary objective of major start-ups and small firms seeking to cut expenses is minimal capital investment. The client is not required to own the services but is free to utilize them. A flexible cost structure can be achieved through reducing fixed expenses. The user can lower charges for new services, upkeep, and operating expenses Public clouds provide the most affordable services since they are standardized and not tailored to the needs of individual users. Due to the fact that they are tailored for the user, private and hybrid clouds are more expensive. A important value proposition for decision-makers going to the cloud is the decrease in cost. As the expansion of data centers requires large expenditures, the cost growth rate also illustrates a cause for moving to the cloud. Depending on how often they utilize cloud computing services, managers can convert their fixed capital investment in data centers to variable expenditures
Market resilience	Businesses may employ cloud computing to swiftly respond to the shifting market conditions. An earlier adjustment to the market might be advantageous for changes, improvements, or new services. 'Companies are always looking for methods to increase their agility so they can respond quickly to market demands. The cloud model promotes quick prototyping and innovation and shortens time to market by enabling organizations to swiftly modify procedures, goods, and services to satisfy shifting consumer demands [6, 34]
Complexity	Simplified complexity for users. With more services, user knowledge does not always need to expand. Services and upgrades are carried out without user input. Due to outsourcing of duty to the provider, business subjects anticipate that cloud computing would simplify IT operations
Low entry barriers	There are no initial expenses. Costs can be kept track of, and using and integrating the services is simple
Tech problems	High-end equipment is not required for cloud computing. Because the cloud computing infrastructure provides computational capacity, small businesses may employ outdated hardware to cut costs. a new hardware requirement that opens up options for users and relies heavily on software to manage resources Better IT alignment and availability of IT skills and development are expectations among businesses. However, another crucial factor that poses a critical problem for businesses is the process of technological literacy in the workforce In terms of service, IaaS is more vendor-responsible than PaaS and calls for more technical knowledge from the user [35]
Connectivity/Accessibility	Every form of gadget may be integrated into cloud providers' architecture with ease

(continued)

Table 2 (continued)

Security	Given that the service is scalable, implementing security on a large scale is more affordable. Effective security systems are enabled by the security implementation. However, in addition to challenges in addressing the complexity of safe setup and a lack of expertise, security and compliance issues continue to be the biggest obstacles to cloud adoption [36, 37]
Rationalization	Outsourced data centers are used. The enterprise's activities no longer include tasks like planning, building, maintaining, and other responsibilities
Efficiency	Cloud computing provides on-demand dynamic provisioning. Resources that are not utilised are instead shared with other users
Client relationships	The effectiveness of Customer Relationship Management (CRM) deployment is becoming more and more dependent on the topic of cloud computing. Therefore, factors like new cloud infrastructure, IT expertise, cloud security, and cost have a significant influence on the performance of CRM systems [34]
The benefits of scale	Cloud providers benefit from economies of scale due to bulk pricing, specialized employees, reduced aggregate capacity, amortization of the initial expenditures, etc. Using economies of scale, providers may offer their services to clients at the lowest possible cost. Additionally, economies of scale enhance security, business continuity, and service effectiveness [38]
Green IT	Utilizing technologies that are begun properly, cloud computing offers the opportunity to conserve energy. In the corporate world of today, green IT is quite important. Digital technologies are predicted to have the ability to reduce worldwide CO2 emissions by 20% by 2030 [39] for various industries. The primary elements that fact the decrease of energy and carbon emissions are the benefits of cloud computing in dynamic provisioning call mother will server usage, data center efficiency, and dynamic resource allocation. It is possible to replace many small data centers with a few large ones that maximize resource use
Agility	Cloud agility places more of an emphasis on security, monitoring, and analysis rather than providing and managing IT resources, saving time and money in the process. [40]

3 Future Business Value of Cloud Computing

3.1 Basic Customer Data Analysis for the Cloud

The three businesses do provide a unique set up of cloud computing infrastructure. The next section examines how well these outriders are already doing in comparison to the high expectations of the IT sector. The three businesses are set apart by their service models. While Netflix and CERN only employ infrastructure-as-a-service, BMW uses both platform-as-a-service and infrastructure-as-a-service. Both CERN

Table 3 Analysis of the outrider companies that have already created useful cloud architectures are analyzed

(a)

Enterprise	BMW	Netflix	CERN
Service models	IaaS, PaaS, corporate SaaS	IaaS	IaaS
Deployment models	Private cloud (Hybrid Cloud)	Public cloud	Private cloud (Hybrid Cloud)
Application field	Information technology service management includes identity management, configuration management, security management, systems management, output management, connectivity management, internal structure management, and employee support services	In 2012, infrastructure including "client information, video suggestions, digital rights management, video encoding, and monitoring system performance" were outsourced to Amazon Management, analysis, availability, and automation	automation of storage and compute pools, Dashboard, image, and identity services Reconstructions of collisions, information about task management, data catalogs, data replication, monitoring, and accounting systems Long-term holding

(b)

Enterprise	BMW	Netflix	CERN
Strategy	Private cloud with open-source software, improved structures thanks to cloud input	Transferring all processes to Amazon web services, and using external sources for open-source input	Private cloud that matches the diverse environment and reliable staff
Vision	Independence from technology and vendors Complete automation User effectiveness, expandability, and contribution to problems	Shared critical workloads in public structures, the growth of cloud computing, and the capacity of businesses to participate and create value	Using the cloud to facilitate scientific cooperation, reduce administration, and implement cooperative hybrid and/or public cloud solutions
Expectations	Integrated seamlessly into structures, infrastructure that is available and resilient, connecting services to business needs Enhancement of security features	Strong system that is unbreakable, as a diversion, data centers Superior data integration standards, core competencies-focused differentiation	Interaction with the current IT infrastructure and improved use, increased safety, data centers that have been automated Processing massive volumes of data

(continued)

Table 3 (continued)

(c)

Enterprise	BMW	Netflix
Benefit	Scalability, cost reductions, accessibility, effectiveness, interoperability, complexity, and business continuity BMW sensor platform, which focuses on the needs of the customer, links cars to the cloud to provide drivers with services that add value by collecting, analyzing, and converting data	Scalability, standardization, availability, and availability zones: three availability zones, guidance to another zone in the event of a zone failure server, efficacy, community involvement, shared expertise to create tools with outside parties, collaboration with Amazon
Level of Value	Utility degree (Business-model-innovation level)	Level of business model innovation
Business Model	IT: moving from a leading to a supporting part Through data collection and service addition, clients are supported and connected Separating the cloud business model from technical difficulties	Structures were entirely outsourced to Amazon, concentrating on key competencies, public buildings created by outside developers and open source Access using the architecture of Amazon web services, users contribute to the development of the open source business model and procedures
Agenda	Technical investigation Determine forthcoming trends, creating automobile prototypes, transfer of innovation and technology from automobiles to infrastructure	Open-source development to increase the commercial value of cloud computing, 100% cloud: using Amazon's infrastructure for all operations

and Netflix created their own applications: While Netflix develops independently and occasionally incorporates user-developed materials, CERN works with a partner.

Taking another look at the enterprise deployment models from the start of their cloud journey. While Netflix built a public cloud architecture, BMW and CERN integrated private clouds with the ability to roll out a public or hybrid cloud later [41]. One of the most crucial elements in getting the most out of cloud computing structures is the integration style. Although a public cloud is required to fully benefit from cloud computing, even outliers like BMW and CERN employed private clouds and maintained their own internal servers. Some businesses are beginning to adopt public frameworks in an effort to get rid of the constraints imposed by security, availability, lock-in, and dependability. But the majority of users emphasized personal, internal solutions. This will hinder cloud computing's ability to overcome its challenges and, in the worst case scenario, stall its progress. To maximize value, businesses must engage with cloud service providers or open-source developers and create a confidence in public cloud systems.

The capacity or age of the systems is the main motivator for moving. BMW collaborated with AWS to develop its cloud solution after deciding that its architecture and design need an upgrade [41]. Digital content was cited by Netflix as one of its justifications for switching to cloud services. Although it requires a lot of storage, digital material is expandable and accessible from anywhere in the globe.

The application area is too narrow to assess a unique value while taking into account the entire cloud computing system. Maximum elasticity, adaptability, and scalability are the desired outcomes. There are no servers to maintain, which lowers costs significantly and improves time to market and agility.

3.2 Plans, Objectives, and Expectations

3.2.1 BMW

Due to aging buildings and steadily increasing data volumes, BMW was compelled to make a modification. BMW had created a system that was designed to complement their organizational structures and help them achieve vendor independence [41].

BMW handled the business continuity throughout the change by concentrating on complete automation, an improvement in productivity, virtualization, security, and device integration. The systems might work along with the current infrastructure. The company was also able to reduce costs, streamline maintenance, and improve energy efficiency.

Since server updates don't result in server downtime, there is a growing expectation that downtimes will be eliminated. Systems that were standardized and simple to use, which offered interoperability, reduced complexity, and simple service measurement, increased user-friendliness [42]. BMW made the decision to integrate the simplest structures rather than create new ones in order to guarantee that complexity does not conflict with the expectation of flexibility.

The company was able to save a significant amount of money as a result. Enterprises taking the same path pose a danger to the full potential of cloud computing services, especially in light of the services' potential for future improvement.

BMW's plan to incorporate cloud computing into their vehicles is an intriguing step for cloud computing. BMW has cloud computing capabilities built into its vehicles and is working to increase their use. Applications transmit data back to BMW while providing consumers with value-added services. BMW gathers data, enabling it to increase its expertise and generate fresh information for study. The client receives extra services, such as information on map data, traffic, and gasoline. BMW took into account the ecosystem, partners, and third parties as enterprise value.

They started a worthwhile effort to outfit their vehicles with cloud computing, but the internal private structure did not compel the growth of cloud computing value [43]. The internal organizational structures provide some of the value anticipated by the IT sector, but they failed to incorporate crucial benefits. It is said that flexibility is constrained in order to lessen complexity. Location independence was overlooked since BMW runs a private cloud out of its own data center. Virtualization has no potential to minimize the number of servers. The in-house data center also has an impact on commitment because it allows for significant investments while also making provider switching impossible [41]. Public cloud architectures offer a less expensive alternative with greater potential for virtualization and scalability, provided that the cost sector does not exhaust the options.

BMW transitioned to the cloud and mostly got what they wanted, but as a real customer, not as a cloud pioneer. Without contributing to the growth of cloud computing itself, BMW creates value propositions from the technology and utilizes it to improve its own structures.

BMW is able to provide genuine value to cloud architectures by putting forth creative ideas and leveraging its financial clout to upgrade IT infrastructure. BMW and AWS have pooled their resources to cooperatively create cloud-enabled solutions that improve productivity, effectiveness, and sustainability throughout the whole automotive life cycle, from car design to after-sales services [44]. BMW's IT systems and databases are affected by data migration and other elements of collaboration, which boosts agility, creates a cutting-edge customer experience, and offers fresh perspectives on the cloud and the IT landscape.

3.2.2 Netflix

In order to achieve a totally outsourced infrastructure, Netflix employs an outsourcing approach. Since 2012, almost all business operations have been outsourced to AWS's infrastructure-as-a-Service platform. In order to benefit from community feedback and build upon open-source goods, platform services are created internally.

Given their outsourcing of practically all crucial workloads to a public cloud, Netflix is revealed as one of the major cloud innovators by their vision and aspirations. Netflix sees itself as a participant who both contributes and gains from the situation.

The company intended to design a system that wouldn't fail and stay away from data centers' distractions. Netflix has a big focus on scalability given the nature of their services. Amazon is a must for Netflix. Amazon Web Services must thus provide trustworthy architecture. The firm is trying to concentrate on its core capabilities by outsourcing every solution available as it transitions to cloud structures [45].

Benefits of cloud computing were customized for Netflix. Due to Amazon's limitless capacity, scalability performs as planned, allowing for quick service changes, dynamic provisioning, and adaptations to fluctuating subscriber numbers. By operating its services from three of Amazon's availability zones, Netflix boosted availability and decreased downtime. Netflix is among Amazon's biggest customers, making it a desirable partner. Amazon responds quickly to Netflix's demands and provides standardized architecture and interfaces to run standardized software for a system that is simple for users and developers to operate. Along with the other elements that Netflix has outsourced, it has also contracted with Amazon Web Services to maintain and secure its infrastructure, saving money [46].

As said, Netflix makes use of cloud computing. Customers access through on-demand self-service architectures, allowing for flexible resource scalability.

Netflix offers great value thanks to pooled resources and measurable services that enable Amazon's pay-as-you-go business model [47]. Throughout the collaboration, Netflix also had issues with the cloud, such as a server section failure or collapse.

Since almost all of Netflix's structures are centralized, the company has a high degree of market flexibility, and Amazon is one of the top cloud innovators [48]. Faster time-to-market, lower complexity, more efficiency, simplification, and fewer technical difficulties are all benefits of centralizing services.

Nearly all of the cloud-related categories outlined by Netflix have been implemented. The company has outsourced its whole operation to the cloud and is using a public deployment strategy. The issue with Netflix is that it promotes the creation of antiquated technologies while ignoring the growth of cloud services. Their structural growth is closely related to the growth of Amazon Web Services [49]. Amazon manages its security system, performs maintenance, and stores the content. When businesses outsource their operations, the future of cloud computing is frequently linked to the supplier. Netflix is still able to create better tools since they list cloud service development as one of their key competencies. Highly developed open-source solutions encourage more businesses to embrace cloud services, which has an impact on how cloud computing continues to evolve.

3.2.3 CERN

When a research showed that their "transistors count [is] doubling every two years" [50], CERN began to consider the idea of cloud computing. In collaboration with OpenStack, the business established a plan to make its systems more manageable and scalable while incorporating a private infrastructure as a service solution. They need computational power that was tailored to their particular environment [50]. The concept of CERN places a lot of emphasis on flexibility and reducing administrative

burdens. In an effort to transform a private cloud into a hybrid cloud, CERN worked with Rackspace to promote innovation [51]. This is in line with the broader goal of the CERN cloud computing infrastructure, which aims to provide "the greatest cloud computing environment for scientific cooperation" by working with Rackspace and open source software [52]. For improved overall usage, CERN wants its cloud infrastructure to communicate with current systems. Because of the rapidly increasing need for infrastructure, CERN anticipates that cloud computing will free up space in its data centers by lowering storage requirements. While facilitating the storage of large volumes of data, sharing services, and streamlining security through simpler service administration.

By being more responsive in its interactions with consumers and dispersing massive processing resources throughout the globe, CERN already benefits from cloud computing. Because of the resources' scalability in the cloud and the scientists' increased flexibility, they are now easily accessible through the self-service portal. The CERN data sets are available to scientists all around the world. Every registered user has access to the research findings.

Structures are quicker to modify when a new service is required, and data sets are faster and constantly available. Due to the virtualization of their services, scientists don't experience any delays. Even running one's own operating system on the cloud infrastructure is an option. Through its cloud, CERN generates operational and resource efficiency. The system has significant cost-saving benefits since it makes better use of already-existing capabilities rather than requiring the construction of new data centers. The ability of some of the infrastructure to stay isolated from the cloud computing network is another advantage of the private or later focused hybrid structure. Sensitive information can be kept on-site at CERN [53].

An intriguing player in the world of cloud computing is CERN. Many of the features and advantages that cloud computing might provide were integrated in their own cloud. But CERN is more open and concentrated on hybrid and public cloud systems than businesses like BMW. Additionally, CERN is continually enhancing cloud systems and has already transformed valuable structures. Since a private cloud hasn't given CERN all of their options, they collaborated to construct a hybrid cloud to get more out of the cloud. CERN must stay on course and keep building its cloud. Data flow from CERN to Oracle via research networks has recently been improved. With the goal of transferring enormous amounts of data, the CERN Openlab team has collaborated with Oracle and GÉANT to create network solutions. Numerous institutions will gain from this collaboration, and a few clients will be able to submit connectivity requests to GÉANT for technical reason and demand confirmation [54].

3.3 Level of Value

The levels of value might be difficult to separate since they occasionally overlap. The categorization provides an overview of the firms' current rankings and their outlook for the future.

The value of the BMW was the lowest of the three outriders. They were wary of transferring their data to a public or hybrid cloud and mainly concentrated on the utility-level benefits that cloud computing architectures may provide. BMW made the decision to incorporate the structure that was the simplest to run rather than the one that offered the most potential for the growth of cloud computing or enterprise value [49]. On the other side, the company is developing ground-breaking cloud computing systems for automobiles, which have the potential to completely transform the automotive industry. Therefore, the degree of value must be divided. BMW's own private cloud utilizes cloud computing's standard capabilities and runs at the utility level. In contrast, the innovation division is functioning at a higher level. The goal is set in motion, but with the most recent actions and the innovation section, it undoubtedly illustrates the business-model-innovation level [54].

However, even when taking into account the expansion of their services, Netflix shows the prototype of the business-model-innovation level. The company migrated all of its activities to the cloud and developed a fully cloud-based business model with a thorough grasp of core and non-core services. Core service is the development of services, not the construction of independent infrastructure. Amazon Web Services serves as the sole source of data for Netflix. With the help of the most seasoned cloud infrastructure provider, who oversees every aspect of the infrastructure, Netflix manages its services [45].

CERN illustrates the procedure at the transformation level in this instance. They needed new methods of operation since their data center could no longer accommodate more resources. Through the virtualization of its services, the firm sped up its business operations and made access possible from anywhere in the world. Scientists now have the chance to collaborate, evaluate, and employ data sets more quickly and effectively. As they continually pushed the development of their cloud computing structures and were interested in new ways to manage their operations, CERN over time evolved into a business-model-innovation organization [51, 55].

Numerous businesses now live up to the promises put forward for cloud computing. In order to maximize their chances of benefiting greatly from cloud computing, businesses are looking for novel solutions. A benefit is that each of the three instances uses open-source software to build their system, allowing other businesses to benefit from it as well. These businesses are collaborating with other users to advance cloud computing, opening up new possibilities [43]. Nevertheless, there are issues with businesses' plans to develop the cloud. Even the outriders mostly concentrate on their own personal growth.

4 Business Plan and Objectives

4.1 Agenda for the Business Models and Use of the Cloud

An ecosystem of businesses and organizations that participate in the cloud computing industry has direct implications for business and cloud agenda. The business strategy of BMW, which strongly relies on customer integration, cooperation, and support, focuses on innovative ways to comprehend client requirements. BMW is confident in its own internal solution since platform and infrastructure collaboration shows the most promise [56].

BMW manages its cloud business through a framework of support and service contracts. They did, however, also create an All-in-One enterprise cloud as part of their efforts to find a way to retain non-sensitive data on-site. They simultaneously incorporate users into their organizational structures to produce useful apps and provide support for them [24]. The customer value proposition is clearly defined by the provision of new and worthwhile services to their clients while firmly maintaining internal organizational structures [54].

This prevented BMW from using cloud computing to increase profit. The company created its own apps and services and only worked with a partner to implement its system. BMW presented cloud computing as a strategic choice, just like any other user, and they were able to reap benefits from it. Although the cloud business model has to evolve to become a true strategic benefit for the enterprise [57].

In order to secure increased customer value, the agenda for gaining a strategic advantage primarily relies on recognizing new trends and implementing new technology solutions. BMW anticipates a significant potential move toward the public cloud in the event of a successful relationship with public cloud providers, taking technological advancements into strategic consideration. This is particularly true since there is a significant demand for network services, there is potential for innovation transfer, and skills and cognitive technologies can evolve quickly [57].

	BMW	Netflix	CERN
Who	Employees, client vehicles	Film	Scientists who have contributed
What	Optimized internal procedures, IT as a premier division, driver-related services	Business-wide outsourcing to Amazon web services, with a focus on key skills	Overcoming the constraints of conventional IT, including scientists from around the globe
How	Private internal cloud, internal frameworks, collaborating for system installation Integration, collaboration, and customer support	Private internal cloud, internal frameworks, collaborating for system installation Integration, collaboration, and customer support	Creating a private internal cloud that can transform into a public or hybrid cloud, internal process improvement, Data that is not sensitive is outsourced

Netflix's business strategy is centered on streamlining procedures. Everything that can be outsourced has been or will be done so. The company totally focuses on its core capabilities, which puts product innovation in the spotlight [58]. In order to increase efficiency, Netflix changed its cost model into a variable cost model through the shift to cloud computing services. Due to the fact that they outsourced its structures to Amazon, they were able to precisely react to the demands of their market. Given that it is inexpensive, beneficial, and quick in terms of the consumer value proposition, it fits the cloud computing business model's perspective. Netflix created its value network in collaboration with Amazon utilizing open-source technologies to build its applications [59]. Netflix adds value by sharing and enhancing its open-source tools with developers across the world. Utilizing newly developed capabilities to administer the core services is made possible by outsourcing resources. When Netflix decided to outsource all of its structures to a public cloud, it became one of the first significant businesses [60].

Netflix offered its products in a creative way. Their goals include creating more useful open-source tools and outsourcing every aspect of their organization. Amazon allows Netflix to highlight its key skills while operating Netflix's security and maintenance system over their structures, presenting a very creative organizational structure. The organization has concentrated on better-developed apps to keep consumers delighted, and the structures are already optimized and contributing [47]. The business strategy is clearly defined and operates flawlessly.

The cloud computing network at CERN, on the other hand, is focused on process optimization and the collaboration and integration of scientists from all over the world to work in a collaborative way. The company has always been interested in creating a cutting-edge cloud computing business model to build an all-encompassing enterprise cloud [50].

Since users rather than consumers are the only ones using cloud computing at CERN, there is no such thing as a customer value proposition. Scientists can collaborate and share their research findings thanks to global access to data and computing capacity. The conventional earning logic is not used at CERN. Since the cloud's primary function is collaboration, a vast value network has been built between its users. Resources and capabilities look for areas for improvement. The choice by CERN to transition to cloud structures required a significant strategic effort. The choice transformed how business was conducted internally and had an impact on infrastructure spending [51, 61]. The Worldwide LHC Computing Grid, the forerunner of the revolution that gave rise to contemporary distributed computing infrastructures and Cloud computing, was designed, deployed, and operated by CERN for the better part of the last 20 years [62, 63].

CERN has an innovative economic model, and the company is keen to enhance its structures with the new possibilities that cloud computing provides.

5 Conclusion

Numerous advantages and benefits of cloud computing have been shown to exceed possible downsides. The three instances demonstrate that cloud computing is performing as expected, despite the fact that even the most innovative companies who created lucrative cloud computing systems were afraid of the new structures, integration of outside parties, and new services. This has shown that the only businesses that can successfully adapt their operational capability to the changing business environment are those that can thrive. The use of the cloud immediately affects the decrease in the likelihood of losing sales and clients, as well as the reinforcement of the benefits of flexibility, low operating expenses, and competition.

The three examined instances showed how closely tied enterprise integration style is to cloud computing. Over the years, Netflix and CERN have sought to be more creative and create the cloud, while BMW has boosted its structures using pre-existing capabilities. Many of the challenges may be overcome by innovative businesses since how businesses integrate plays a significant part in the overall growth. The behaviors and tactics of these outriders made it possible for new viewpoints to emerge, which helped the cloud overcome many of its challenges. These challenges are directly related to the users' confidence and integration with third parties. Users' challenges are therefore challenges that suppliers must also overcome. Cloud computing may achieve maximum performance and value by having a reliable architecture and framework that operates within the limits rather than just removing the barriers caused by various problems.

The corporate benefit of cloud computing has two facets that guarantee collaboration for improvement. The trust problems will always exist because of the boundaries between these sides, preventing cloud computing from reaching its full potential. At times, the growth of cloud computing is somewhat influenced by neither consumers nor suppliers. Other problems impede progress by the way they operate.

As foreseen by the IT sector, cloud computing now provides a boost for every business, evolving into a hosting paradigm. There are still obstacles and frontiers to cross, and recent years have shown that cloud computing is advancing towards doing so.

References

1. Penzel, D.: Enterprise value of cloud computing an analysis from provider's and customer's perspective and challenges for a future development, Universität Wien, Masterstudium Betriebswirtschaft (2014). https://utheses.univie.ac.at/detail/32268/
2. Penzel Masterarbeit, D.: Enterprise value of cloud computing—an analysis from provider's and customer's perspective and challenges for a future development. Master of Science (M.Sc.), Wien (2014). https://phaidra.univie.ac.at/download/o:1314968
3. Why should one prefer the public cloud over the private cloud in 2022?—EnterisCloud, 31 Aug 2021. https://enteriscloud.com/prefer-the-public-cloud-over-the-private-cloud/. Accessed 16 Sept 2021

4. Gartner says more than half of enterprise IT spending in key market segments will shift to the cloud by 2025. Gartner. https://www.gartner.com/en/newsroom/press-releases/2022-02-09-gartner-says-more-than-half-of-enterprise-it-spending
5. Ramel, B.D.: Report: risk management lags in changing cloudscape. Virtualiz. Rev. (2021). https://virtualizationreview.com/articles/2021/12/15/cloud-risk.aspx. Accessed 16 Jan 2022
6. Berman, S.J., Kesterson-Townes, L., Marshall, A., Srivathsa, R.: How cloud computing enables process and business model innovation. Strat. Leadership **40**(4), 27–35 (2012). https://doi.org/10.1108/10878571211242920
7. Kaya, F., van den Berg, M., Wieringa, R., Makkes, M.: The banking industry underestimates costs of cloud migrations. In: 2020 IEEE 22nd Conference on Business Informatics (CBI), Antwerp, Belgium, June 2020, pp. 300–309
8. Cloud Select Industry Group | Shaping Europe's digital future. https://digital-strategy.ec.europa.eu/en/news/cloud-select-industry-group. Accessed 19 Jan 2022
9. 'EDPB approves first EU GDPR code of conduct for cloud service providers. https://www.cms-lawnow.com/ealerts/2021/06/edpb-approves-first-eu-gdpr-code-of-conduct-for-cloud-service-providers. Accessed 19 Jan 2022
10. 2022 state of the cloud report by Flexera Press release. https://www.flexera.com/about-us/press-center/2022-state-of-the-cloud-report-by-flexera. Accessed 01 Apr 2022
11. Klein, D.: Micro-segmentation: securing complex cloud environments. Netw. Secur. **2019**(3), 6–10 (2019). https://doi.org/10.1016/S1353-4858(19)30034-0
12. Lambropoulos, G., Mitropoulos, S., Douligeris, C.: A review on cloud computing services, concerns, and security risk awareness in the context of digital transformation. In: 2021 6th South-East Europe design automation, computer engineering, computer networks and social media conference (SEEDA-CECNSM), Sept 2021, pp 1–6
13. Udhaya Chandrika, S., Pramananda Perumal, T.: Modified ECC for secure data transfer in multi-tenant cloud computing. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **14**(6), 76–88 (2022). https://doi.org/10.5815/ijcnis.2022.06.06
14. Niraula, T., Pokharel, A., Phuyal, A., Palikhel, P., Pokharel, M.: Quantum computers' threat on current cryptographic measures and possible solutions. Int. J. Wirel. Microw. Technol. (IJWMT) **12**(5), 10–20 (2022). https://doi.org/10.5815/ijwmt.2022.05.02
15. Ogidiaka, E., Ogwueleka, F.N., Irhebhude, M.E., Orji, U.: Local cloud computing service adoption in Nigeria: challenges and solutions. Int. J. Inf. Technol. Comput. Sci. (IJITCS) **14**(4), 1–13 (2022). https://doi.org/10.5815/ijitcs.2022.04.01
16. Bitkom: Cloud-monitor 2015. Cloud-Computing in Deutschland – Status quo und Perspektiven', p. 40 (2015)
17. Cloud computing's value proposition. Maximizing Business Value with AWS. A Cloud Guru, 07 Mar 2019. https://acloudguru.com/blog/engineering/cloud-computings-value-proposition-maximizing-business-value-with-aws. Accessed 01 Apr 2022
18. Han, L.: Market acceptance of cloud computing—an empirical analysis of market structure, price models and service requirements (2009)
19. Neicu, A.-I., Radu, A.-C., Zaman, G., Stoica, I., Răpan, F.: Cloud computing usage in SMEs. An empirical study based on SMEs employees perceptions. Sustainability **12**(12) (2020)
20. Hu, Z., Odarchenko, R., Gnatyuk, S., Zaliskyi, M., Chaplits, A., Bondar, S., Borovik, V.: Statistical techniques for detecting cyberattacks on computer networks based on an analysis of abnormal traffic behavior. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **12**(6), 1–13 (2020). https://doi.org/10.5815/ijcnis.2020.06.01
21. Hu, Z., Gnatyuk, S., Okhrimenko, T., Tynymbayev, S., Iavich, M.: High-speed and secure PRNG for cryptographic applications. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **12**(3), 1–10 (2020). https://doi.org/10.5815/ijcnis.2020.03.01
22. Cassimiro Nascimento, D., Santos Pires, C.E., Brasileiro Araújo, T.: A theoretical model for estimating entity resolution costs in cloud computing environments. Discret. Math. Theor. Comput. Sci. **1** (2018). https://hal.archives-ouvertes.fr/hal-01809639. Accessed 09 June 2020 [Online]

23. Sampson, D., Chowdhury, M.M.: The growing security concerns of cloud computing. In: 2021 IEEE International Conference on Electro Information Technology (EIT), May 2021, pp. 050–055. https://doi.org/10.1109/EIT51626.2021.9491902
24. Khorraminia, M., Lesani, Z., Ghasvari, M., Rajabion, L., Darbandi, M., Hassani, A.: A model for assessing the impact of cloud computing on the success of customer relationship management systems (case study: agricultural companies). DPRG (2019). https://doi.org/10.1108/DPRG-03-2019-0016
25. Weinhardt, C., et al.: Cloud computing—a classification, business models, and research directions. Bus. Inf. Syst. Eng. **1**(5), 391–399 (2009). https://doi.org/10.1007/s12599-009-0071-2
26. Mesbahi, M.R., Rahmani, A.M., Hosseinzadeh, M.: Reliability and high availability in cloud computing environments: a reference roadmap. Hum. Cent. Comput. Inf. Sci. **8**(1), 20 (2018). https://doi.org/10.1186/s13673-018-0143-8
27. Chang, V., Bacigalupo, D., Wills, G., De Roure, D.: A categorisation of cloud computing business models. In: 2010 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, Melbourne, Australia, pp. 509–512 (2010). https://doi.org/10.1109/CCGRID.2010.132
28. The customer value proposition of the cloud. Incremental Economics, 17 Sept 2020. https://www.incrementaleconomics.com/what-is-the-customer-value-proposition-of-the-cloud-and-why-are-the-big-getting-bigger/. Accessed 12 Apr 2021
29. Novais, L., Maqueira Marín, J.M., Moyano-Fuentes, J.: Lean production implementation, cloud-supported logistics and supply chain integration: interrelationships and effects on business performance. IJLM **31**(3), 629–663 (2020). https://doi.org/10.1108/IJLM-02-2019-0052
30. DaSilva, C.M., Trkman, P., Desouza, K., Lindič, J.: Disruptive technologies: a business model perspective on cloud computing. Technol. Anal. Strat. Manag. **25**(10), 1161–1173 (2013). https://doi.org/10.1080/09537325.2013.843661
31. Molodetska, K., Veretiuk, S., Gregus, M., Fedushko, S., Syerov, Y.: Simulating the interaction of social internet services actors using irregular attractors. Procedia Comput. Sci. **198**, 688–693 (2021)
32. Renugadevi, T., Geetha, K., Muthukumar, K., Geem, Z.W.: Optimized energy cost and carbon emission-aware virtual machine allocation in sustainable data centers. Sustainability **12**(16), 6383 (2020). https://doi.org/10.3390/su12166383
33. Das, H., Barik, R.K., Dubey, H., Roy, D.S.: Cloud Computing for Geospatial Big Data Analytics: Intelligent Edge, Fog and Mist Computing. Springer (2018)
34. Kryvinska, N., Poniszewska-Marańda, A. (eds.): Developments in Information & Knowledge Management for Business Applications: Volume 2, vol. 376. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-76632-0
35. IaaS vs PaaS vs SaaS: explanation, differences, and comparison. Apriorit. https://www.apriorit.com/white-papers/405-saas-iaas-paas. Accessed 08 Apr 2021
36. Hasimi, L.: Cost-effective solutions in cloud computing security. In: Developments in Information & Knowledge Management for Business Applications : Volume 2. Springer International Publishing, Cham, pp. 177–202 (2021). https://doi.org/10.1007/978-3-030-76632-0_5
37. Farooque, M., Patidar, K., Kushwah, R., Saxena, G.: Survey and analysis of cloud data management and security. 2020./paper/Survey-and-analysis-of-cloud-data-management-and-Farooque-Patidar/d6ea2f5bda9f28aae00ffb6c05394a876b573306. Accessed 23 Feb 2021
38. Masip-Bruin, X., et al.: mF2C: the evolution of cloud computing towards an open and coordinated ecosystem of fogs and clouds. In: Schwardmann, U., Boehme, C., Heras, D.B., Cardellini, V., Jeannot, E., Salis, A., Schifanella, C., Manumachu, R.R., Schwamborn, D., Ricci, L., Sangyoon, O., Gruber, T., Antonelli, L., Scott, S.L. (eds.) Euro-Par 2019: Parallel Processing Workshops, vol. 11997. Springer International Publishing, Cham, pp. 136–147 (2020). https://doi.org/10.1007/978-3-030-48340-1_11
39. EPIC: Digital action = climate action: 8 ideas to accelerate the twin transition. DIGITALEUROPE. https://www.digitaleurope.org/resources/digital-action-climate-action-8-ideas-to-accelerate-the-twin-transition/. Accessed 08 Apr 2022

40. Castillo, D.A.F.: Key advantages of cloud agility. Cloud Computing Technologies, 30 Aug 2020. https://cloudcomputingtechnologies.com/key-advantages-of-cloud-agility/. Accessed 08 Apr 2021
41. Cloud computing/Netflix case study CIS 6300 Samantha Morrow—free download pdf. https://nanopdf.com/download/cloud-computing-netflix-case-study-cis-6300-samantha-morrow_pdf. Accessed 08 Apr 2022
42. AWS and BMW Group Team up to accelerate data-driven innovation. https://www.press.bmwgroup.com/global/article/detail/T0322118EN/aws-and-bmw-group-team-up-to-accelerate-data-driven-innovation?language=en. Accessed 08 Apr 2022
43. Penzel, D., Kryvinska, N., Strauss, C., Gregu, M.: The future of cloud computing: a SWOT analysis and predictions of development. In: 2015 3rd International Conference on Future Internet of Things and Cloud, Aug 2015, pp. 391–397 (2015). https://doi.org/10.1109/FiCloud.2015.102
44. The BMW Group and AWS Team Up to accelerate data-driven innovation in the automotive industry. Amazon.com, Inc.—Press Room. https://press.aboutamazon.com/news-releases/news-release-details/bmw-group-and-aws-team-accelerate-data-driven-innovation/. Accessed 09 Feb 2022
45. Singh, H., Agarwal, A.: Leveraging the revolutionary paradigm of cloud computing: the case of Netflix. Mumukshu J. Hum. **6**, 177–185 (2014)
46. Voigt, K.-I., Buliga, O., Michl, K.: Entertainment on demand: the case of Netflix. In: Business Model Pioneers, pp. 127–141. Springer International Publishing, Cham (2017). https://doi.org/10.1007/978-3-319-38845-8_11
47. Sinha, P.: Cloud computing using AWS: an analysis. IJCS **5**(6), 27 (2020). https://doi.org/10.17010/ijcs/2020/v5/i6/157500
48. Blog, N.T.: Four reasons we choose Amazon's cloud as our computing platform. Medium, 18 Apr 2017. https://netflixtechblog.com/four-reasons-we-choose-amazons-cloud-as-our-computing-platform-4aceb692afec. Accessed 10 June 2021
49. Williams, M.: BMW to use AWS cloud computing software to improve supply chain visibility. Automotive Logistics (2020). https://www.automotivelogistics.media/news/bmw-to-use-aws-cloud-computing-software-to-improve-supply-chain-visibility/41392.article. Accessed 08 Jan 2021
50. Bell, T., et al.: Scaling the CERN openstack cloud. J. Phys. Conf. Ser. **664**(2), 022003 (2015). https://doi.org/10.1088/1742-6596/664/2/022003
51. CERN case study. Google Cloud
52. Rackspace and CERN openlab bring clouds around the world together to aid scientific discovery. Rackspace Technology. https://www.rackspace.com/en-gb/newsroom/rackspace-cern-openlab-bring-clouds-around-world-together-aid-scientific-discovery. Accessed 10 Apr 2022
53. Cordeiro, C., et al.: CERN computing in commercial clouds. J. Phys: Conf. Ser. **898**, 082030 (2017). https://doi.org/10.1088/1742-6596/898/8/082030
54. Gonzalez, C.: Connected automobiles the cloud drives with you. ATZ Elektron. Worldw. **13**(3), 50–52 (2018). https://doi.org/10.1007/s38314-018-0033-x
55. Bisong, A., Rahman, S.: [1101.5613] an overview of the security concerns in enterprise cloud computing. https://arxiv.org/abs/1101.5613
56. Kukkamalla, P.K., Bikfalvi, A., Arbussa, A.: The new BMW: business model innovation transforms an automotive leader. JBS **42**(4), 268–277 (2021). https://doi.org/10.1108/JBS-02-2020-0021
57. Strategy for the future. The Cloud report. News, articles, interviews and tests, 17 Feb 2020. https://the-report.cloud/strategy-for-the-future. Accessed 11 Feb 2021
58. Leung, A., Spyker, A., Bozarth, T.: Titus: introducing containers to the Netflix cloud. Commun. ACM **61**(2), 38–45 (2018). https://doi.org/10.1145/3152529
59. Bermbach, D., et al.: On the future of cloud engineering. In: 2021 IEEE International Conference on Cloud Engineering (IC2E), San Francisco, CA, USA, Oct 2021, pp. 264–275. https://doi.org/10.1109/IC2E52221.2021.00044

60. Mathur, M.: AWS: Netflix case study. Medium, 21 Sept 2020. https://muditmathur121.medium.com/aws-netflix-case-study-40eea075c3f9. Accessed 01 Apr 2022
61. CERN hybrid cloud empowers breakthrough research. Intel. https://www.intel.com/content/www/us/en/customer-spotlight/stories/cern-large-hadron-collider-customer-story.html. Accessed 13 Apr 2021
62. Jedrzejewska, M., Zjawiński, A., Karovič, V., Ivanochko, I.: Cloud CRM system for mobile virtual network operators. Advances in Intelligent Systems and Computing, vol. 1035. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29035-1_39
63. Di Meglio, A., Doser, M., Frisch, B., Grabowska, D., Pierini, M., Vallecorsa, S.: CERN quantum technology initiative strategy and roadmap. Zenodo, Oct 2021. https://doi.org/10.5281/ZENODO.5571809

Are Code Review Smells and Metrics Useful in Pull Request-Level Software Defect Prediction?

Krzysztof Baciejowski, Damian Garbala, Szymon Zmijewski, and Lech Madeyski

Abstract The process of software code review is a well-established practice in software engineering. Previous research identified quality metrics for code review. However, to our knowledge, this paper is the first that uses those review smells and metrics as predictors in software defect prediction. We used review process metrics used in other studies as well as created new ones. A machine learning model is fed with various process metrics (code review) and product metrics (software code) to be able to predict if a pull request might introduce a defect. For the GitHub repositories examined, the mean absolute errors for predictive models were equal to 0.26 (for the model built on product metrics only), 0.29 (for model built on review metrics only), and 0.25 (for model built on combined metrics). The results indicate that the quality of the code review conveys additional valuable information that can be utilized to better predict software defects. In fact, review metrics alone appeared to be almost as good predictors of software defects as investigated since a long time and widely used software product metrics.

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1 Introduction

The software development process is bound to encounter unexpected defects in the code base. The frequency of introducing these defects should be reduced by the code review process. In fact, some studies have shown that greater coverage for code review and greater participation reduce the chances of introducing a bug to code [3, 22, 23]. Unfortunately, this process is often not able to filter all defective code. The defective code that passes through the code review process might be the result of poor review quality. The process of solving defects is very expensive, and, therefore, the possibility of in-advance determination if the code changes might introduce a bug would be invaluable.

In September 2020, Doğan [11] identified seven bad practices that could be correlated with a lower quality of reviews and named them "code review smells". Six of them were then described in detail and searched for in open-source projects. The results of this research were later published in [12]. Unfortunately, the article did not address the correlation between the quality of the review measured by "code review smells" and inducing defects.

Using these sources as a reference point, our objective was to utilize code review smells and metrics to predict inducing software defects with pull requests. Although there are some papers on the use of code smells as predictors of software defects, see [26], to our knowledge, this paper is the first that uses code review smells to predict software defects.

2 Background

Doğan and Tüzün [12] have identified seven and defined six smells of code reviews. The aim of this research is to check whether, based on code review smells and metrics, one is able to predict if a pull request might induce a defect. To achieve this goal, the following steps were executed:

- gathering information on other review qualities which possibly impact probability of inducing software defect,
- finding alternative definitions of those qualities,
- finding already used code review metrics,
- introducing new code review metrics,
- checking whether those code review metrics and smells can be helpful to predict software defects.

For the search for relevant literature, the following research questions were defined:

RQ1 Is it possible to utilize code review smells as predictors of software defects for pull requests?

RQ2 Is it possible to derive metrics from the code review smells defined by Doğan and Tüzün [12]?

RQ3 Is it possible to utilize code review quality metrics as predictors of software defects for pull requests?

2.1 Relevant Literature

In order to answer the defined research questions, code review smells and metrics needed to be gathered. During the study selection process, search strings were defined that cover the subject area, titles, abstracts, and keywords. The results of this query were then analyzed for relevance; possibly relevant sources were read in full to check whether they can be helpful when pursuing the goal of this paper.

2.1.1 Search Strings

All subjects of our interest can be described with the following search string:

```
TITLE-ABS-KEY(code-review* AND (quality OR metric* OR
smell*OR impact)) AND (PUBYEAR > 2014) AND (LIMIT-TO(
SUBJAREA, "COMP")) AND (LIMIT-TO(LANGUAGE, "English"))
```

2.1.2 Results of Research for Relevant Literature

After evaluating the aforementioned search string on April 4, 2022 Scopus returned 341 results. 28 were labeled possibly relevant based on their title and abstract, but after full-text analysis it appeared that only 16 of them contained information on review-related smells and metrics.

Figure 1 illustrates the process of literature selection; Appendix contains lists of articles accepted during first and second screening stage.

2.1.3 Already Defined Metrics

Table 1 contains information on explicitly defined metrics and those deduced from relevant articles that are considered to be related to the review and possibly influence code quality.

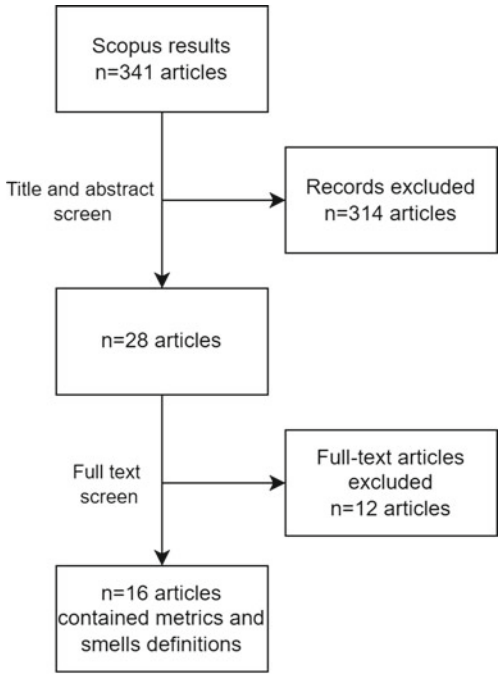

Fig. 1 Literature selection process

3 Methods and Materials

The conducted research consisted of several stages. First, we select repositories to evaluate, after that we aim to reproduce the research by Doğan and Tüzün [12] by implementing code review smells in our code base, then we develop new metrics that potentially might have impact on inducing a bug. Afterwards, we import metrics from the dataset [17]. In the end, we feed a machine learning model with metrics and smells.

3.1 Reproduction of Doğan and Tüzün Research

The process of reproduction does not fully reflect the process provided by Doğan and Tüzün [12], because our strategy relies on a larger amount of data. That is why the data are stored in a database. Data on pull requests, users, files, their changes, and reviews are retrieved from GitHub by means of the GitHub API for chosen repositories and saved to the database. Then it is processed according to the specification provided by the aforementioned paper.

Table 1 Metrics and smells found in or deduced from relevant literature

Smell/Metric	Type	Description	Source
No review	Smell	PR closed without review	[21, 22, 28, 29]
Self review	Smell	PR contains only self-review	[21, 22, 29]
Number of hasty reviews	Metric	Number of reviews with checked 200loc/h	[21, 22, 29]
Number of short reviews	Metric	Number of short reviews	[9]
Number of superficial reviews	Metric	Number of superficial reviews	[9]
Number of reviews without inline comments	Metric	Number of negative reviews without inline comments	[9]
Number of reviews	Metric	Number of reviews	[3, 9, 10, 19–21, 25, 28, 29, 31–33]
Number of author responses	Metric	Number of author responses to reviews	[19]
Number of reviews to churn ratio	Metric	Number of reviews divided by number of changed loc	[21]
Review window	Metric	Time PR was opened for reviewing	[25, 29, 31, 33]
Review window to churn ratio	Metric	Time PR was opened for reviewing divided by changed loc	[21]
Review delay	Metric	Time between PR was opened and first review	[10, 28, 31–33]
Number of reviewers	Metric	Number of unique reviewers	[3, 10, 19–21, 25, 31–33]
Number of non-author reviewers	Metric	Number of reviewers who didn't change code to be merged	[9, 31, 33]
Disagreement ratio	Metric	Ratio of non-approval reviews	[9, 31, 33]
Number of revisions	Metric	Number of commits after PR was opened	[16, 21, 28, 31, 33]
Number of revisions without review	Metric	Number of non-commented commits added in review window	[31, 33]
Churn during code review	Metric	Loc changed during review window	[31, 33]

(continued)

Table 1 (continued)

Smell/Metric	Type	Description	Source
Negative sentiment in reviews	Metric	Determined coefficient of negative sentiment	[9]
Confused reviews	Metric	Coefficient of confusion based on keywords	[9, 13]
Number of discussion observers	Metric	Number of discussion observers	[19]
Important keywords used	Metric	# of positive minus # of negative keywords	[6]
Reviewing time	Metric	Average time spent on reviewing	[16, 28]
Review pace	Metric	Average churn reviewed per hour	[31]
Shepherding time	Metric	Average time spent on review-related activities	[16]

Table 2 Reproduction results for Doğan and Tüzün research

Smell	VS code (%)	Desktop (%)	Tensorflow (%)
Lack of review	57.57	14.25	12.48
Missing PR description	24.51	11.21	43.93
Large changeset	7.97	5.25	9.94
Sleeping review	40.13	41.39	47.82
Ping-pong	4.19	10.67	9.08
At least one of: – lack of review – missing PR description – large changeset – sleeping review – ping-pong	83.37	63.16	81.89
Review buddies*	3.25	7.39	11.71

*Smell *Review buddies* was defined but not measured by Doğan and Tüzün [12].

For reproduction, VS Code, Tensorflow, and GitHub Desktop repositories were chosen. The smell detection results are shown in Table 2 and are consistent with the original research.

3.2 Metrics

Doğan and Tüzün [12] have divided the metrics based on their extraction/calculation method into ones extracted directly from pull requests, ones regarding single reviews (but still collected for each pull request) and those calculated for the whole repository (also assigning the results to single pull requests). Some additional metrics might also be implemented as part of future work.

3.2.1 Imported Metrics

We imported product metrics assigned to commits in the dataset from the article by Keshavarz and Nagappan [18]. These metrics are:

- change date
- # of lines added
- # of lines deleted
- # of files touched
- # of directories touched
- # of of subsystems touched
- change entropy
- # of of distinct developers touched files
- the average time from last change
- # of of unique changes in files
- change author experience
- change author
- recent experience
- change author subsystem experience

3.2.2 New Metrics

We defined several metrics of the code review process to feed the machine learning model with:

- **Number of reviewers**
  It simply checks how many reviewers have reviewed a pull request.
- **Number of reviewers different than the pull-request author**
  This metric is an improvement of the Number of reviewers metric. In the calculation, it excludes the reviewer who created a pull request. It is worth mentioning that the author of a pull request may be different from the author of changes in code (especially when multiple people have been contributing to the code).
- **Number of reviews**
  This metric evaluates the number of reviews (without checking their authors) for a given pull request.

- **Number of commits after pull-request creation**
  This metric counts commits that were added after the pull request creation date. It is assumed that such commits introduce improvements and are the result of submitted reviews. It is also expected that a pull request containing these commits is less likely to introduce a defect.
- **Number of lines changed after pull-request creation**
  Reviews requesting some changes should result in new commits with improvements. This metric counts the number of lines that were changed as a result of a code review. It is worth mentioning that all changes introduced after a pull request's creation date are considered improvements, no matter if there were already some reviews submitted.
- **Review length (number of characters)**
  Review length metric counts the number of characters in each review for a pull request. At the time of implementation, it is still unclear whether a bigger or smaller number of characters is better. This metric is related to some other code review metrics, e.g., Number of reviews and some project metrics, e.g., number of changes lines.
- **Review window per changed lines**
  This metric takes into account both the time passed between opening and closing a pull request and the number of changed lines in order to calculate the ratio between those two values. This way it is possible to establish more flexible threshold values to mark a pull request as smelly.
- **Reviewed lines per hour**
  Reviewed lines per hour metric measures how many lines were changed for a given pull request and calculates a ratio between this value and the opening hour a the pull request.
- **Review length per lines of code**
  This metric is an amplification of the Review length metric. It calculates the ratio between the number of characters in all reviews in a given pull request and the number of changed lines.
- **Review window**
  This metric is extracted by calculating the time passed between opening and closing a pull request. It has a few known flaws, as it does not consider the actual time spent reviewing a request (limitations are mentioned in Sect. 5). Hence, the request can be open for so long that it will be considered smelly, but still be reviewed superficially.
- **Review window per line**
  Reviews that last too long are considered smelly, but their duration should be related to number of changed lines. Obviously, it is possible to change a lot of lines of code barely changing the program logic or not changing it at all (e.g. by renaming a variable or a function). Such cases should rather be the minority.

3.3 Data Preparation

We used the dataset by Keshavarz [17] to assign a value if a commit induces a bug. This dataset consisted of commits from 12 repositories of Apache projects. We have downloaded the data of pull requests and reviews for the commits. With the data, three random forest models can be trained.

We encountered a problem with granularity. We need to know if a pull request induces a misbehaviour, not a commit (as it is in the dataset). We solved the granularity problem deciding that a pull request is bug-inducing if one of the commits is. The product metrics were assigned to the pull request using trimmed means of 10%.

3.4 Implementation

We implemented models generation with functions detecting smells and evaluating metrics from review-related data using Python scripts. Our implementation can be found in Github repository as explained in Appendix

4 Results

Three models were created, trained on 513 pull requests (PRs) and tested on 171 remaining entries, and these models will be marked as:

M1 based on metrics from dataset by [18],
M2 based on five of the smells created by [12] (*large changesets* smell is not related to the quality of reviews, thus was omitted) and new metrics (see Sect. 3.2.2) we developed and
M3 model which combines both aforementioned sources of PR evaluators.

Table 3 presents errors obtained when predicting whether PR is buggy for each of the models for all GitHub repositories that exist in the dataset by [18]. As one can see, M2 has similar performance to M1 and is more or less able to determine whether PR introduced bugs. It allows us to answer positively to RQ1 and RQ3.

In order to determine which metrics are most important for our experimental models, metrics importance was evaluated based on mean decrease in impurity (MDI). For M2, as shown in Fig. 2, the most important features included *review window* (41%), *review window per line* (26%), *reviews characters per line of code* (10%) and *total number of reviews characters* (9%). For the combined model (M3), the *lines added* were the most influential (33%), the rest of the metrics and smells had an importance below 5% (e.g., *review window* 4%), this is shown in Fig. 3. It can be explained for some metrics with their boxplots for buggy and non-buggy pull requests (see Appendix), where all other than *review window* and *review window per*

Table 3 Errors for prepared models

Error type	M1	M2	M3
Mean absolute error	0.26	0.29	0.25
Mean squared error	0.13	0.16	0.13
Root mean squared error	0.37	0.40	0.36

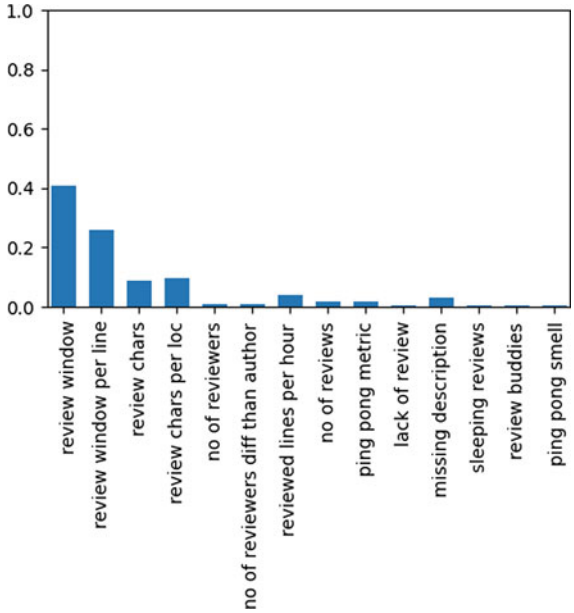

Fig. 2 Metrics and smells importance for M2

line do not show significant differences between those two groups. The entire report is available in Appendix, including figures.

As can be seen in Fig. 4, some metrics have a very high correlation; therefore, the ones with the highest correlation could be removed.

In the context of the study, we formulated the following research questions:

RQ1 Is it possible to utilize code review smells as predictors of software defects for pull requests?
Yes, they were successfully utilized in software defects predicting models M2 and M3 as shown in Sect. 4.

RQ2 Is it possible to derive metrics from code review smells defined by Doğan and Tüzün?
Yes, we have derived 11 metrics what was presented in Sect. 3.2.2.

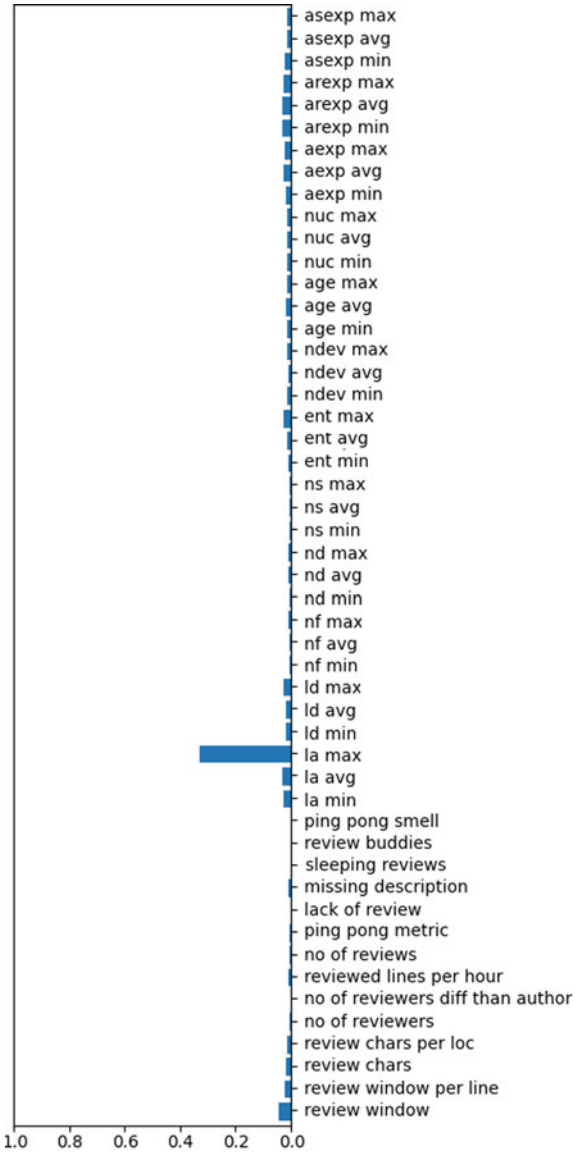

Fig. 3 Metrics and smells importance for M3

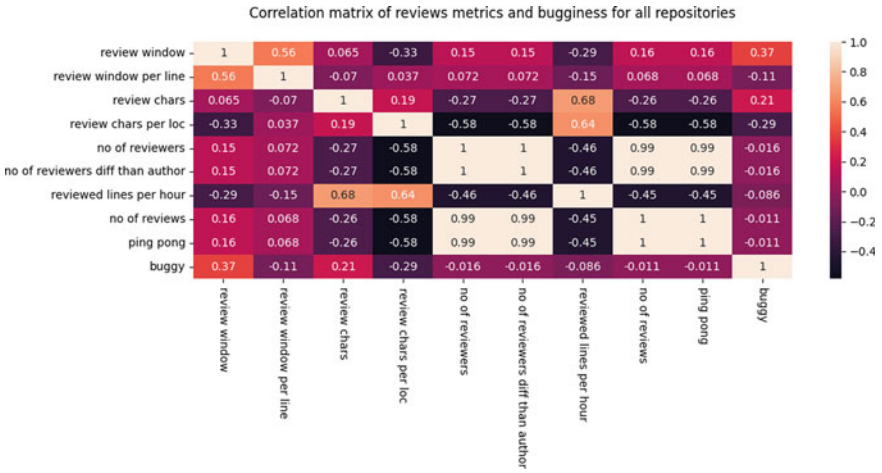

Fig. 4 Correlation of metrics from Sect. 3.2.2

RQ3 Is it possible to utilize code review quality metrics as predictors of software defects for pull requests?
Yes, they were successfully utilized in software defects predicting models M2 and M3 as shown in Sect. 4.

5 Discussion

Analysis of nine Apache repositories showed code review smells and metrics can be used to predict bug introduction with accuracy similar to model based on product-related metrics. This opens the possibility to enhance existing models by adding a whole new category of metrics and smells, which would be related to the review process.
During the process of developing the model certain limitations were identified:

- Some commits that the dataset included could not be found from the GitHub API. That caused the model to use less training and testing data than it would be relevant.
- The dataset and our research had different levels of granularity; therefore, the metrics for commit could not be easily applied on a pull request.
- GitHub does not measure the time that a reviewer has spent on a review, hence this attribute is not accessible for our research. Other review tools—for instance, Crucible—include the time spent. This is especially important, considering the fact that the metrics based on time—*review window* appeared to be the most impactful.

This work could have more reliable results and a broader scope if these limitations were overcome.

There are areas where this work can be improved and included in future works:

- *User metrics*
  such as reviewer reputation based on number of reviews made, the number of projects contributed, etc.
- *Review content*
  NLP (natural language processing) of reviews to estimate their relevance and assess code changes based on reviewers' opinions.
- *Conflicting reviews*
  Calculated by checking if multiple reviews regarding the same changes in code approve and disapprove them.
- *Dataset*
  The results might differ once more data is provided, as mentioned in limitations. Then the introduced model could be used to retrieve more relevant information on the impact of the developed metrics.

It was discovered that reviewing process descriptors, such as those in Table 1, have high potential when it comes to predicting bug introduction and should be included in relevant models.

6 Conclusions

All posed research questions were answered and the results open up a new promising research direction.

Using the answers and models defined in Sect. 4, it was shown that the review smells and metrics allow predicting pull request bugginess to a similar extent as classic software product metrics; however, this model is not fully satisfying and performs better with more review metrics or when combined with software product metrics. Thus, standard product metrics still remain important features of prediction models. There is also room to introduce improvements and modifications to the method used in this investigation, as described in Sect. 5.

CRediT Authorship Contribution Statement

Krzysztof Baciejowski: Software, Data curation, Investigation, Writing—original draft, Writing—review and editing, Visualization. **Damian Garbala**: Software, Investigation, Writing—original draft **Szymon Zmijewski**: Software, Investigation, Writing—original draft **Lech Madeyski**: Conceptualization, Methodology, Writing—review and editing, Supervision.

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Appendix

Reproduction

Code utilized to perform reproduction of [12] is available on Github (github.com/pwr-pbr22/M7/tree/reproduction). Scripts used to prepare models are available in the same repository on the main branch (github.com/pwr-pbr22/M7). Reproduction instructions are available in respective README files.

Relevant Literature Search

As mentioned in Sect. 2.1.2 28 articles passed title and abstract screen, 16 of them passed full text screen and 12 were excluded. These articles can are listed below.

- Articles which passed title and abstract screen, but were excluded during full text screen: [1, 2, 4, 5, 7, 8, 14, 15, 24, 27, 30, 34].
- Articles which passes title and abstract screen and were deemed relevant after full text screen: [3, 6, 9, 10, 13, 16, 19–22, 25, 28, 29, 31–33].

Appendix

Appendix includes the report, located below, from the implemented Jupyter Notebook.

Model based solely on data from *A Large Dataset for Just-In-Time Defect Prediction*

```
C:\Users\kbaci\AppData\Local\Programs\Python\Python310\lib\site-packages\pandas\core\indexes
\base.py:6982: FutureWarning: In a future version, the Index constructor will not infer numer
ic dtypes when passed object-dtype sequences (matching Series behavior)
  return Index(sequences[0], name=names)
```

Selected training and testing sets

```
Training features shape:         (513, 36)
Training labels shape:           (513,)
Testing features shape:          (171, 36)
Testing labels shape:            (171,)
```

Prediction errors

```
Mean absolute error:            0.26
Mean squared error:             0.13
Root Mean squared error:        0.36
```

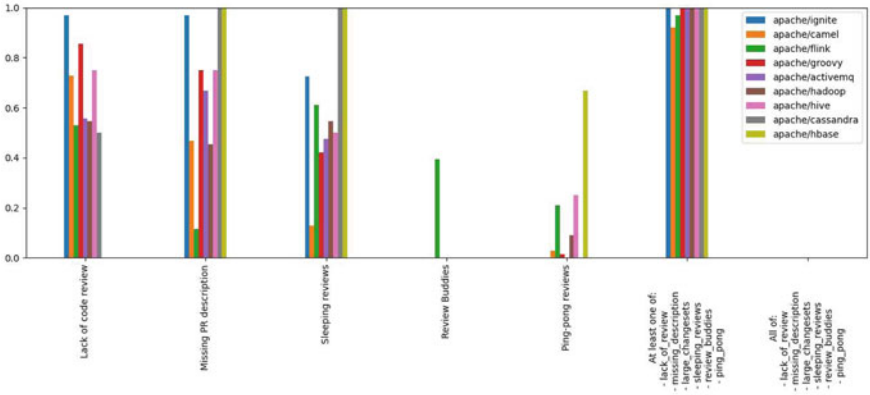
Model based on our metrics and smells

Smells

Share of smelly pulls

```
Smell / repository              ignite          camel           flink           groovy
activemq        hadoop          hive            cassandra       hbase
Lack of code review                 96.77%          72.66%          52.97%          85.53%
55.56%      54.55%          75.0%           50.0%           0.0%
Missing PR description              96.77%          46.76%          11.35%          75.0%
66.67%      45.45%          75.0%           100.0%          100.0%
Sleeping reviews                    72.58%          12.95%          61.08%          42.11%
47.62%      54.55%          50.0%           100.0%          100.0%
Review Buddies                       0.0%            0.0%           39.46%           0.0%
0.0%          0.0%           0.0%            0.0%            0.0%
Ping-pong reviews                    0.0%            2.88%          21.08%           1.32%
0.0%        9.09%          25.0%            0.0%           66.67%
At least one of:
- lack_of_review
- missing_description
- large_changesets
- sleeping_reviews
- review_buddies
- ping_pong                          100.0%          92.09%          96.76%          100.0%
100.0%      100.0%         100.0%           100.0%          100.0%
All of:
- lack_of_review
- missing_description
- large_changesets
- sleeping_reviews
- review_buddies
- ping_pong                           0.0%            0.0%            0.0%            0.0%
0.0%          0.0%           0.0%            0.0%            0.0%
```

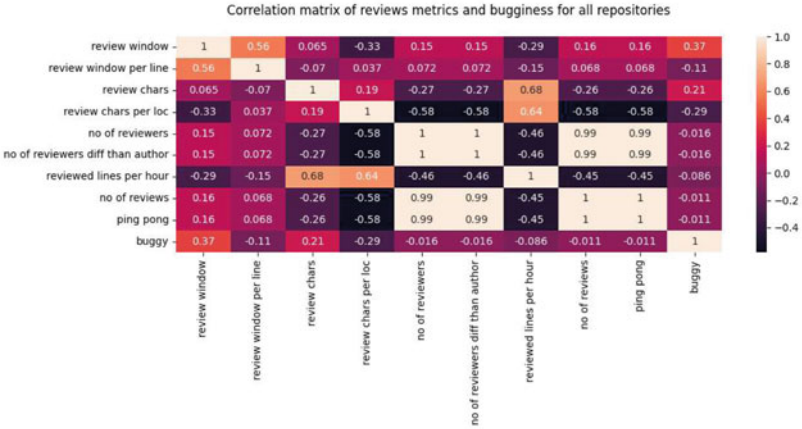
Figure



Metrics

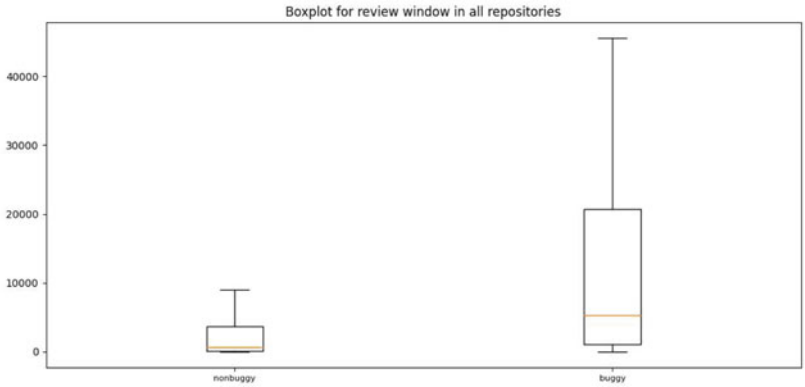
Correlation between metrics

Figure

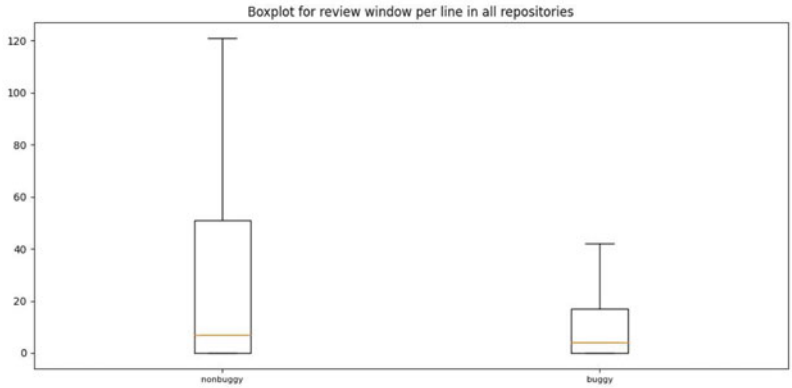


Boxplots for different metrics

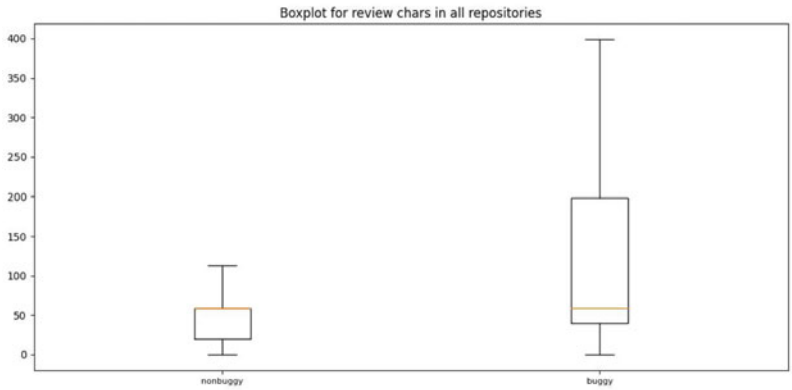
Figure



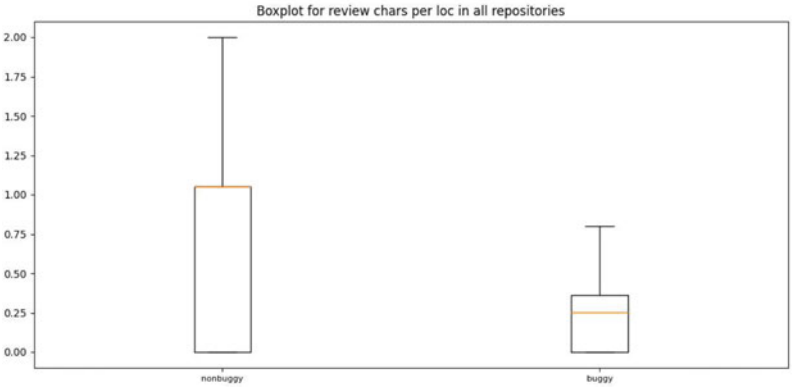
Figure



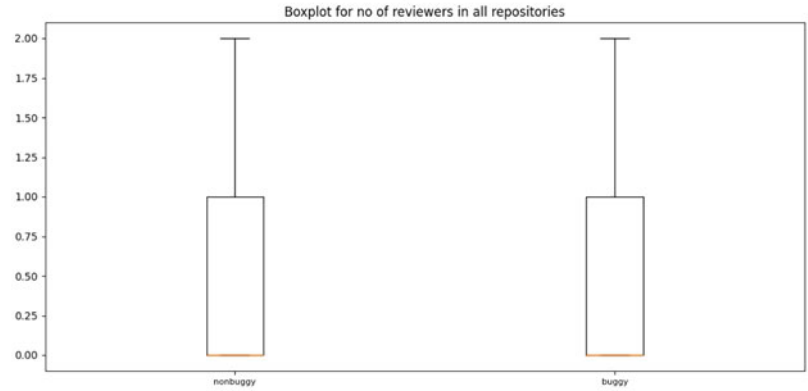
Figure



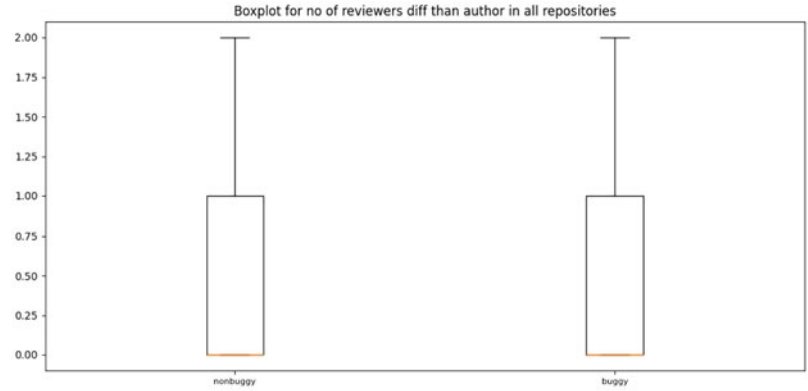
Figure



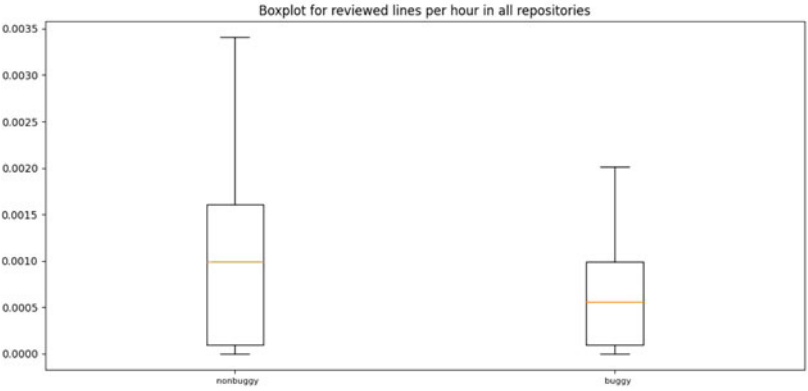
Figure



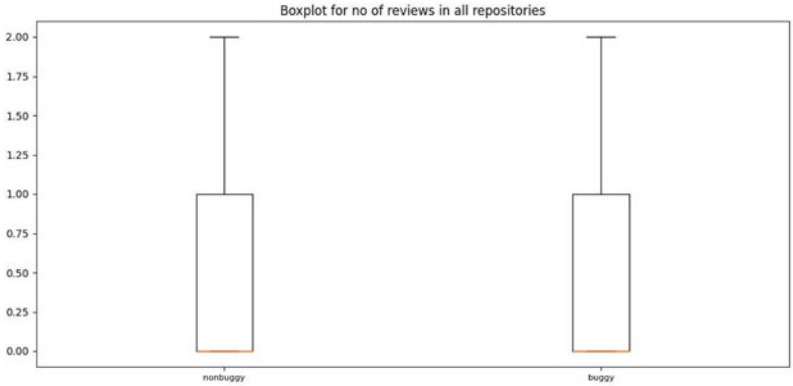
Figure



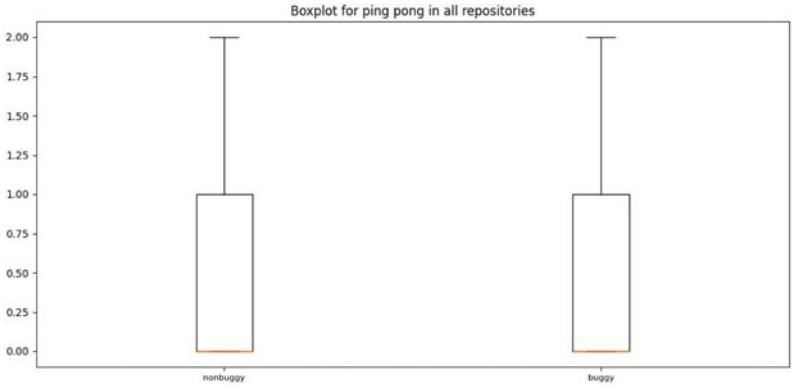
Figure



Figure



Figure



Model

Selected training and testing sets

```
Training features shape:        (513, 14)
Training labels shape:          (513,)
Testing features shape:         (171, 14)
Testing labels shape:           (171,)
```

Prediction errors

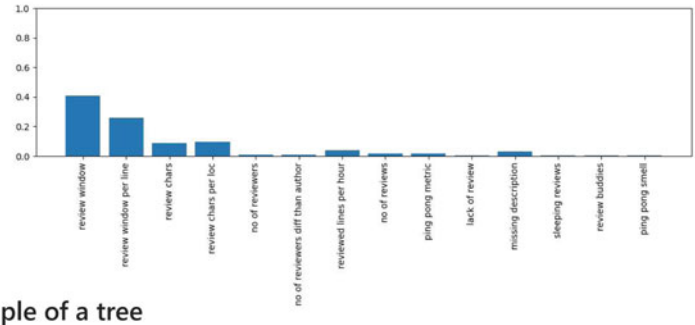
```
Mean absolute error:            0.29
Mean squared error:             0.16
Root Mean squared error:        0.4
```

Metrics importance

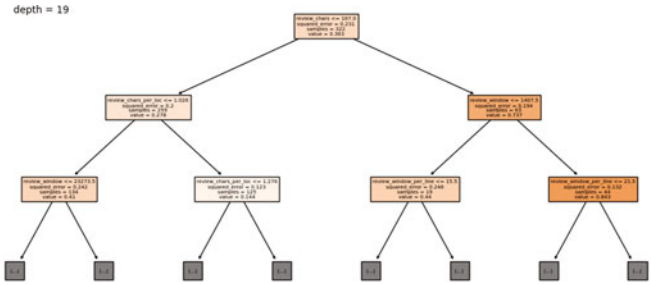
```
Metrics                        Importance
review window                  0.41
review window per line         0.26
review chars per loc           0.1
review chars                   0.09
reviewed lines per hour        0.04
missing description            0.03
no of reviews                  0.02
ping pong metric               0.02
no of reviewers                0.01
no of reviewers diff than author 0.01
sleeping reviews               0.01
review buddies                 0.01
lack of review                 0.0
ping pong smell                0.0
```

```
C:\Users\kbaci\AppData\Local\Temp\ipykernel_8764\4159194392.py:3: UserWarning: FixedFormatter
should only be used together with FixedLocator
  ax.set_xticklabels(list(map(lambda e: e.replace('_',' '), feature_list)),rotation="vertica
l")
```

Figure



Example of a tree



Combined model

```
C:\Users\kbaci\AppData\Local\Programs\Python\Python310\lib\site-packages\pandas\core\indexes
\base.py:6982: FutureWarning: In a future version, the Index constructor will not infer numer
ic dtypes when passed object-dtype sequences (matching Series behavior)
  return Index(sequences[0], name=names)
```

Selected training and testing sets

```
Training Features Shape: (513, 50)
Training Labels Shape: (513,)
Testing Features Shape: (171, 50)
Testing Labels Shape: (171,)
```

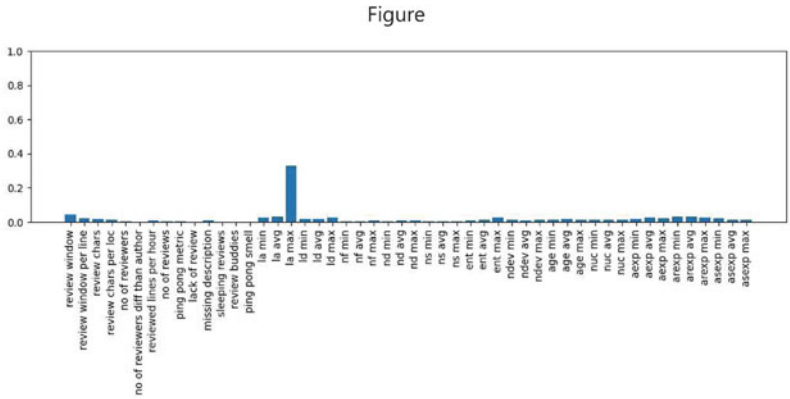
Prediction errors

```
Mean absolute error:            0.25
Mean squared error:             0.13
Root Mean squared error:        0.36
```

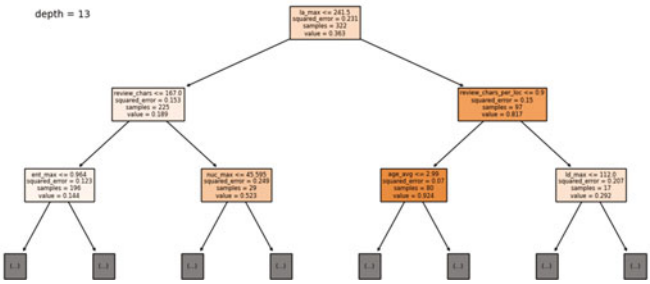
Metrics importance

```
Metrics                          Importance
la max                           0.33
review window                    0.04
la min                           0.03
la avg                           0.03
ld max                           0.03
aexp avg                         0.03
arexp min                        0.03
arexp avg                        0.03
arexp max                        0.03
review window per line           0.02
review chars                     0.02
ld min                           0.02
ld avg                           0.02
ent max                          0.02
age avg                          0.02
nuc min                          0.02
aexp min                         0.02
aexp max                         0.02
asexp min                        0.02
asexp avg                        0.02
review chars per loc             0.01
reviewed lines per hour          0.01
missing description              0.01
nf avg                           0.01
nf max                           0.01
nd avg                           0.01
nd max                           0.01
ns avg                           0.01
ent min                          0.01
ent avg                          0.01
ndev min                         0.01
ndev avg                         0.01
ndev max                         0.01
age min                          0.01
age max                          0.01
nuc avg                          0.01
nuc max                          0.01
asexp max                        0.01
no of reviewers                  0.0
no of reviewers diff than author 0.0
no of reviews                    0.0
ping pong metric                 0.0
lack of review                   0.0
sleeping reviews                 0.0
review buddies                   0.0
ping pong smell                  0.0
nf min                           0.0
nd min                           0.0
ns min                           0.0
ns max                           0.0
```

```
C:\Users\kbaci\AppData\Local\Temp\ipykernel_8764\4159194392.py:3: UserWarning: FixedFormatter
should only be used together with FixedLocator
  ax.set_xticklabels(list(map(lambda e: e.replace('_',' '), feature_list)),rotation="vertica
l")
```



Example of tree



References

1. Alami, A., Cohn, M.L., Wasowski, A.: Why does code review work for open source software communities? In: Proceedings of the 41st International Conference on Software Engineering. IEEE Press, ICSE '19, pp. 1073–1083 (2019). https://doi.org/10.1109/ICSE.2019.00111
2. Baum, T., Liskin, O., Niklas, K., Schneider, K.: Factors influencing code review processes in industry. In: Proceedings of the 2016 24th ACM SIGSOFT International Symposium on Foundations of Software Engineering. Association for Computing Machinery, New York, NY, USA, FSE 2016, pp. 85–96 (2016). https://doi.org/10.1145/2950290.2950323
3. Bavota, G., Russo, B.: Four eyes are better than two: on the impact of code reviews on software quality. In: 2015 IEEE International Conference on Software Maintenance and Evolution (ICSME), pp. 81–90 (2015). https://doi.org/10.1109/ICSM.2015.7332454
4. Baysal, O., Kononenko, O., Holmes, R., Godfrey, M.W.: Investigating technical and non-technical factors influencing modern code review. Empir. Softw. Eng. **21**(3), 932–959 (2016). https://doi.org/10.1007/s10664-015-9366-8
5. di Biase, M., Bruntink, M., Bacchelli, A.: A security perspective on code review: the case of chromium. In: 2016 IEEE 16th International Working Conference on Source Code Analysis and Manipulation (SCAM), pp. 21–30 (2016). https://doi.org/10.1109/SCAM.2016.30
6. Bosu, A., Greiler, M., Bird, C.: Characteristics of useful code reviews: an empirical study at Microsoft. In: 2015 IEEE/ACM 12th Working Conference on Mining Software Repositories, pp. 146–156 (2015). https://doi.org/10.1109/MSR.2015.21

7. Bosu, A., Carver, J.C., Bird, C., Orbeck, J., Chockley, C.: Process aspects and social dynamics of contemporary code review: insights from open source development and industrial practice at Microsoft. IEEE Trans. Softw. Eng. **43**(1), 56–75 (2017). https://doi.org/10.1109/TSE.2016.2576451
8. Caulo, M., Lin, B., Bavota, G., Scanniello, G., Lanza, M.: Knowledge transfer in modern code review. Association for Computing Machinery, New York, NY, USA, pp. 230–240 (2020). https://doi.org/10.1145/3387904.3389270
9. Chouchen, M., Ouni, A., Kula, R.G., Wang, D., Thongtanunam, P., Mkaouer, M.W., Matsumoto, K.: Anti-patterns in modern code review: symptoms and prevalence. In: 2021 IEEE International Conference on Software Analysis, Evolution and Reengineering (SANER), pp. 531–535 (2021). https://doi.org/10.1109/SANER50967.2021.00060
10. Davila, N., Nunes, I.: A systematic literature review and taxonomy of modern code review. J. Syst. Softw. **177**(110), 951 (2021)
11. Doğan, E.: Towards a taxonomy of code review smells. Master's Thesis, Bilkent University. https://hdl.handle.net/11693/54183
12. Doğan, E., Tüzün, E.: Towards a taxonomy of code review smells. Inf. Softw. Technol. **142**(106), 737 (2022)
13. Ebert, F., Castor, F., Novielli, N., Serebrenik, A.: Confusion detection in code reviews. In: 2017 IEEE International Conference on Software Maintenance and Evolution (ICSME), pp. 549–553 (2017). https://doi.org/10.1109/ICSME.2017.40
14. Ebert, F., Castor, F., Novielli, N., Serebrenik, A.: Confusion in code reviews: reasons, impacts, and coping strategies. In: 2019 IEEE 26th International Conference on Software Analysis, Evolution and Reengineering (SANER), pp. 49–60 (2019). https://doi.org/10.1109/SANER.2019.8668024
15. Efstathiou, V., Spinellis, D.: Code review comments: language matters. In: Proceedings of the 40th International Conference on Software Engineering: New Ideas and Emerging Results. Association for Computing Machinery, New York, NY, USA, ICSE-NIER '18, pp. 69–72 (2018). https://doi.org/10.1145/3183399.3183411
16. Egelman, C.D., Murphy-Hill, E., Kammer, E., Hodges, M.M., Green, C., Jaspan, C., Lin, J.: Predicting developers' negative feelings about code review. In: 2020 IEEE/ACM 42nd International Conference on Software Engineering (ICSE), pp. 174–185 (2020)
17. Keshavarz, H., Nagappan, M.: ApacheJIT: a large dataset for just-in-time defect prediction (2022a). https://doi.org/10.5281/zenodo.5907847
18. Keshavarz, H., Nagappan, M.: Apachejit: a large dataset for just-in-time defect prediction. ArXiv abs/2203.00101 (2022b)
19. Kononenko, O., Baysal, O., Guerrouj, L., Cao, Y., Godfrey, M.W.: Investigating code review quality: do people and participation matter? In: 2015 IEEE International Conference on Software Maintenance and Evolution (ICSME), pp. 111–120 (2015). https://doi.org/10.1109/ICSM.2015.7332457
20. Kononenko, O., Baysal, O., Godfrey, M.W.: Code review quality: how developers see it. In: 2016 IEEE/ACM 38th International Conference on Software Engineering (ICSE), pp. 1028–1038 (2016). https://doi.org/10.1145/2884781.2884840
21. Krutauz, A., Dey, T., Rigby, P.C., Mockus, A.: Do code review measures explain the incidence of post-release defects? Empir. Softw. Eng. **25**(5), 3323–3356 (2020). https://doi.org/10.1007/s10664-020-09837-4
22. McIntosh, S., Kamei, Y., Adams, B., Hassan, A.E.: The impact of code review coverage and code review participation on software quality: a case study of the qt, vtk, and itk projects. In: Proceedings of the 11th Working Conference on Mining Software Repositories. Association for Computing Machinery, New York, NY, USA, MSR 2014, pp. 192–201 (2014). https://doi.org/10.1145/2597073.2597076
23. McIntosh, S., Kamei, Y., Adams, B., Hassan, A.E.: An empirical study of the impact of modern code review practices on software quality. Empir. Softw. Eng. **21**(5), 2146–2189 (2016). https://doi.org/10.1007/s10664-015-9381-9

24. Morales, R., McIntosh, S., Khomh, F.: Do code review practices impact design quality? A case study of the qt, vtk, and itk projects. In: 2015 IEEE 22nd International Conference on Software Analysis, Evolution, and Reengineering (SANER), pp. 171–180 (2015). https://doi.org/10.1109/SANER.2015.7081827
25. Paul, R., Turzo, A.K., Bosu, A.: Why security defects go unnoticed during code reviews? A case-control study of the chromium OS project. In: 2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE), pp. 1373–1385 (2021). https://doi.org/10.1109/ICSE43902.2021.00124
26. Piotrowski, P., Madeyski, L.: Software defect prediction using bad code smells: a systematic literature review. In: Poniszewska-Marańda, A., Kryvinska, N., Jarząbek, S., Madeyski, L. (eds.) Data-Centric Business and Applications: Towards Software Development (Volume 4), vol. 40 of book series Lecture Notes on Data Engineering and Communications Technologies, pp. 77–99. Springer International Publishing, Cham (2020). https://doi.org/10.1007/978-3-030-34706-2_5
27. Rahman, M.M., Roy, C.K., Kula, R.G.: Predicting usefulness of code review comments using textual features and developer experience. In: 2017 IEEE/ACM 14th International Conference on Mining Software Repositories (MSR), pp. 215–226 (2017). https://doi.org/10.1109/MSR.2017.17
28. dos Santos, E.W., Nunes, I.: Investigating the effectiveness of peer code review in distributed software development based on objective and subjective data. J. Softw. Eng. Res. Dev. **6**(1), 14 (2018). https://doi.org/10.1186/s40411-018-0058-0
29. Shimagaki, J., Kamei, Y., Mcintosh, S., Hassan, A.E., Ubayashi, N.: A study of the quality-impacting practices of modern code review at Sony mobile. In: 2016 IEEE/ACM 38th International Conference on Software Engineering Companion (ICSE-C), pp. 212–221 (2016)
30. Sri-iesaranusorn, P., Kula, R.G., Ishio, T.: Does code review promote conformance? A study of openstack patches. In: 2021 IEEE/ACM 18th International Conference on Mining Software Repositories (MSR), pp. 444–448 (2021). https://doi.org/10.1109/MSR52588.2021.00056
31. Thongtanunam, P., McIntosh, S., Hassan, A.E., Iida, H.: Investigating code review practices in defective files: an empirical study of the GT system. In: 2015 IEEE/ACM 12th Working Conference on Mining Software Repositories, pp. 168–179 (2015). https://doi.org/10.1109/MSR.2015.23
32. Thongtanunam, P., McIntosh, S., Hassan, A.E., Iida, H.: Review participation in modern code review. Empir. Softw. Eng. **22**(2), 768–817 (2017). https://doi.org/10.1007/s10664-016-9452-6
33. Uchôa, A., Barbosa, C., Oizumi, W., Blenilio, P., Lima, R., Garcia, A., Bezerra, C.: How does modern code review impact software design degradation? An in-depth empirical study. In: 2020 IEEE International Conference on Software Maintenance and Evolution (ICSME), pp. 511–522 (2020). https://doi.org/10.1109/ICSME46990.2020.00055
34. Zanaty, F.E., Hirao, T., McIntosh, S., Ihara, A., Matsumoto, K.: An empirical study of design discussions in code review. In: Proceedings of the 12th ACM/IEEE International Symposium on Empirical Software Engineering and Measurement. Association for Computing Machinery, New York, NY, USA, ESEM '18 (2018). https://doi.org/10.1145/3239235.3239525

User Reactions and Localization in the Video Game Industry: Developer and Publisher Dominances and Regional Release Date and Review Text Specifics

Sandra Boric and Christine Strauss

Abstract To find out whether there is a dominance in game releases and reception of Japanese game developers and publishers on a console by a Japan-based manufacturer, we analysed Nintendo Switch rating score and rating number data from German, U.S.-American, and Japanese Nintendo- and Amazon-websites. This study's results reveal that although *Nintendo* as a publisher and developer has the most games on the system, and although most of the top five games by rating numbers were developed by Japan-based studios, the overall top five publishers and developers are not as strongly Japan-dominated. We further present localization-related analyses, namely by release dates and reviews (i.e., customer feedback). Retrieved release dates from the three selected countries show a slight tendency of games being released earlier in Japan, and a strong tendency of games being released in autumn and the pre-Christmas season in all three regions. To standardize a manual sentiment analysis of review texts, we derive 12 gaming-related categories: (1) *Economic (monetary) factor*, (2) *Genre*, (3) *Audio design*, (4) *Story*, (5) *Game characters*, (6) *Visual presentation*, (7) *Author background information*, (8) *Game background information*, (9) *Game design*, (10) *Constructive feedback*, (11) *No constructive feedback*, and (12) *Sense of objective review and review structure*. We then assign review texts to one or more of those categories. Found similarities between German, U.S.-American, and Japanese review texts are the mentioning of an economic (monetary) factor, of author and game background information, and of audio design. All the analysed texts contain some constructive feedback, and almost all texts further mention some aspects of game design. U.S. reviewers mention game genres more frequently, but their texts have less of a sense of objective review or review structure, and no U.S.-reviewer mentions a game's *difficulty*. German reviewers mention game developers less frequently, and two of three review texts mentioning the game's target audience

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are German. Japanese reviewers mention visual aspects less but story and game characters more frequently. Overall interpretations reveal that half of each region's texts is written in a casual manner.

1 Introduction

As markets outside of a publisher's local market can bear massive sales potential, publishers are increasingly looking for ways to maximize their sales abroad. A way of accelerating those efforts is by publishing international versions of their games, with translations into several languages [1].

There can be different agendas and expectations when it comes to the localization of a game [2]. In the video game industry, *localization* refers to the process of translating a game into another language. It can further encompass even a redesign of the game, or additional features added to accommodate the translation. Localization can require intensive work if a game contains culturally specific references that need to be 'corrected' (i.e., content-related), or if it lacks accented characters (e.g., for Russian or Japanese language) or international keyboard layouts [1] (i.e., technical features-related).

Despite these efforts, 'international' or localized versions of games are frequently perceived as lacklustre by gamers. In comparison, the original source version often times has an overall better quality and gameplay experience, because its elements (e.g., user interface, story, voice acting, and gameplay) end up being less harmonious after transitioning into another language or country version. Those non-original versions are regularly prone to, e.g., containing spelling errors, incorrect translations, not translated text (i.e., having sudden foreign language-text snippets in a localized version), and out-of-context voice acting [1]. These issues are the motivation for this study at hand which focuses on localization specifics, regional differences, and developer and publisher dominances in the video game industry.

1.1 Developer and Publisher Dominances in the Video Game Industry

In 2016, video game hardware and software manufacturer Sony moved the headquarters of its PlayStation videogame unit from Japan to California as it wanted to further accelerate its business growth and was seeing the highest growth potential in the U.S.A. [3, 4]. There have been past studies of console game publishers encompassing a mixture of both American and Japanese businesses and cultures [5, 6]. Sony is being described as a multinational company with more shareholders outside of Japan than within, but its corporate governance and strategic planning

still being impacted by Japan [7]. Regarding Sony's console game focus in particular, when comparing the launch titles of, e.g., the *PlayStation 2* to the *PlayStation 4* or *PlayStation 5* [8], a trend is noticeable of less launch titles being developed by Japanese studios on the latter two. Also, Sony has had, e.g., varying degrees of third-party support on its *PlayStation 1*, *PlayStation 2*, and *PlayStation 3* consoles compared to its competitors Microsoft and Nintendo [9]. The question arises whether a company that is both a game developer for a console as well as the console's manufacturer is dominant when it comes to said console's game ratings. And what does the reception (i.e., received number of ratings and rating scores) of Japanese and Western game developers and publishers look like on a console by a Japan-based manufacturer? Is there is a dominance of Japanese game developers and publishers on a console by a Japan-based manufacturer? And since there are some peculiarities in release dates, e.g., games being released in Japan significantly earlier than in the West [10, 11], are there any peculiarities regarding games' release dates in different regions on a console by a Japan-based manufacturer?

To explore these questions, we chose Japan, Germany, and the U.S.A. as countries to be compared in this study due to these countries being traditionally dominant in the video game industry [12–16]. We collected data from those three regions using the official *Nintendo*- and *Amazon*-websites to answer the following five research questions:

(1) Where are the headquarter locations of the top-three publishers and developers with the highest *number of games* released on the Nintendo Switch console?
(2) In which country were the top-five games by *absolute number of Amazon-ratings* developed (i.e., developer headquarter location)?
(3) Where are the headquarter locations of the top-five publishers and developers by *absolute* and *average number of Amazon-ratings*?
(4) Are there any differences in the distribution of Nintendo Switch games' *release dates* (by year and month) in the three selected countries?
(5) Which release years and release months accumulate the highest *average number of Amazon-ratings* and *average Amazon-rating scores*?

1.2 Regional Differences in Customer Feedback for Video Games

McAuley & Leskovec [17] point out that customer feedback often comes in the form of a numeric rating accompanied by a review text, but that traditional analysis methods often discard this review text. This results in the review text that justifies a customer's rating being ignored [17]. Regarding customer feedback for video games, whether reviewers mention, e.g., a game's audio design, story, characters, or visual presentation can be vital information for certain parties such as game developers and institutions which are investing into gaming R&D.

Furthermore, there can be regional differences in customer feedback. Kitami et al. [18] mention that, e.g., it can be difficult for games which sell well in Japan to also

become best-sellers elsewhere, and that there are differences between Japanese and U.S.-American customers when it comes to the most popular game genres. Differences from different regions in mentioning these aspects in review texts can indicate differences in regional preferences or in foci when it comes to user expectation. A qualitative content analysis of review texts retrieved from different regions ideally uncovers such regional peculiarities.

Our study therefore additionally contains a qualitative content analysis of selected Amazon-review texts from Germany, the U.S.A., and Japan. The objective of this qualitative content analysis is to answer the following research question:

(6) What are some similarities and differences of selected video game *review texts* from amazon.de, amazon.com, and amazon.co.jp?

This last research question serves as an analysis on user-level, to investigate regional similarities and differences in customer feedback (i.e., review texts) left for Nintendo Switch games on the three selected countries' Amazon website version.

1.3 Choice of Countries for Comparison, and Focus on Nintendo

We chose the U.S.A. and Japan for analysis because they are among the strongest markets for console games in North America and Asia, respectively [13, 19]. Germany was also included in order to contribute to the research of German-speaking consumers of video games.

A comparison of various game consoles by companies such as Sony, Nintendo, and Microsoft reveals some discrepancies in video game sales and applied strategies [20–23] which could be an underlying cause for differing numbers of reviews and rating scores received on Amazon, thus we decided to select only one of these companies for analysis. We chose Nintendo because lists of its released games and further data for each game can be found on its official website versions for Germany (i.e., nintendo.de), the U.S.A. (i.e., nintendo.com), and Japan (i.e., nintendo.co.jp) [24]. We did not choose Sony for analysis since the *Sony Interactive Entertainment* company has its headquarters located in the U.S.A. as of 2022 [25]. Its transition of market focus and its adoption of an American style management and of a new corporate vision was deemed slow but steady and continuous throughout the decades as well as encompassing products that exceed video games [7, 26–30]. Due to its profile, Sony is described as being less tied to a specific nation or product [7]. Nintendo, on the contrary, has maintained its headquarters in Japan since its foundation in 1889 and has had its focus on video games and the entertainment industry for decades [31–35]. Therefore, we chose Nintendo for analysis.

For comparison's sake, our study requires chosen games to have available entries on all three selected countries' Amazon website version. Thus, we decided to focus solely on Nintendo's current *Nintendo Switch* console after conducting a pre-survey in October 2020 that revealed a limited Amazon-availability of games on even the

very next Nintendo console released prior to the Nintendo Switch—i.e., the *Nintendo 3DS*.

2 Material and Methods

We collected data for this study using the three selected countries' official Amazon and Nintendo websites. It should be noted that there is no independent company behind the Austrian site amazon.at, but that it instead belongs to Germany and has the same range of products as amazon.de [36]. As of April 23rd, 2022, typing "amazon.at" or "amazon.ch" into the web browser automatically redirects to amazon.de. And just like amazon.at belongs to Germany [36], the official Austrian Nintendo website nintendo.at and Swiss Nintendo website nintendo.ch are operated by *Nintendo of Europe GmbH ("Nintendo")* located in Frankfurt am Main in Germany [37, 38]. Therefore, any results obtained by analysing data retrieved from the German websites amazon.de and nintendo.de can be regarded as representative of all German-speaking consumers, including those in Austria and Switzerland. However, to ease the readability of this study, results of data retrieved from amazon.de and nintendo.de refer to "Germany" or "German users" only.

2.1 Amazon as Data Source for Reception and Localization Data

We used Amazon as a data source since the intended comparisons required the same kind of data from all three selected countries, and Amazon offers an official website version for those three countries: amazon.de, amazon.com, and amazon.co.jp. We further chose Amazon because it has a high number of Nintendo Switch games listed,[1] and because many of its listed items have entries with customer reviews assigned. And some of those reviews are verified via Amazon's *verified purchase*-system which marks reviews of customers who bought the product on Amazon to counterfeit fake

[1] By accessing amazon.de, clicking on *Alle Kategorien* (ger., all categories), then on *Filme, Serien, Musik & Games* (ger., movies, tv-series, music & games), and further on *Spiele* (ger., games), the amazon.de-games site is accessed. There, a list of available Nintendo Switch games can be found by unchecking the checkbox *Nicht verfügbare Titel einschließen* (ger., include non-available titles), and by clicking on *Spiele* (ger., games). After applying these filters, the amazon.de-results list states that it contains "more than 1,000 results" for available Nintendo Switch games. Accordingly, the amazon.com-games site is accessed by selecting *Video Games* in the *Shop By Department*-section. By choosing *Nintendo Switch*, unchecking the checkbox *Include Out of Stock*, and clicking on *Games*, the thus obtained amazon.com-results list also contains "over 1,000 results" for available Nintendo Switch games. Lastly, the amazon.co.jp-games site is accessed by clicking on *DVD, Music & Games* in the *Shop by Category*-section, and then on *TV Games* in the *Games*-section. Going to *Nintendo Switch* and then to *Switch Games*, and further unchecking the checkbox *Include Out of Stock* shows a results list of "over 3,000 results" for available Nintendo Switch games.

reviews [39]—as those are, just like, e.g., fake news on social media, an example for problematic untrustable online data [40]. Therefore, we deemed Amazon a suitable source to retrieve rating data from. Past studies have already underlined Amazon's value and usefulness as a data source [41, 42].

Although other platforms such as *Metacritic* can also serve as data sources for, e.g., rating scores and number of ratings, and although Metacritic has been used in past studies [43–50], we concluded that Metacritic is unsuitable as a data source due to its controversial weight assignment to reviews that is furthermore not made public [51–54], and due to a revealed relationship on Metacritic between higher scores and higher sales of games [55, 56]. Furthermore, in contrast to Amazon's *Amazon Verified Purchase* label, Metacritic has no such label nor entry requirements for users to leave ratings or reviews for products, which enables users to easily create multiple accounts and assign scores to games without providing any reasoning or explanations [57].

2.2 Choice of Review Entries

To answer our study's six research questions, we first had to derive a list of Nintendo Switch games from an official Nintendo-website so that we could retrieve data for games on that list from the German, U.S.-American, and Japanese Amazon-website versions (i.e., amazon.de, amazon.com, and amazon.co.jp). The following explains the choices made in this study regarding the data collection.

During the data retrieval on the websites of Nintendo and Amazon, we considered only those games for analysis that are currently *available* and that are the *physical version* of a game. We decided to consider only *available* games after conducting some manual checks which revealed that, e.g., some Amazon-entries that were not available lacked some data needed for this study. We also considered only Amazon-entries of *physical versions* because mixing and comparing physical and digital versions of a game could cause some underlying disparities in the results (e.g., different distributions and prices and thus also rating numbers and rating scores).

The first step was to choose an official Nintendo-website to derive a games list of Nintendo Switch games from. We did not use nintendo.com to derive this list from because even though this site has an "At retail"-filter option, we manually checked the obtained nintendo.com-results list after applying this filter and found that the list still included some digital-only software. By using the filter option "Einzelhandelsversion" (ger., retail version) on nintendo.de, however, we indeed obtained a results list of games that all have a physical version and were not digital-only. On nintendo.co.jp, we did not find any useful filter options at all. Therefore, we used a results list obtained from nintendo.de with 460 currently *available physically* released Nintendo Switch games—with applied filter options "jetzt erhältlich" (ger., now available) and "Einzelhandelsversion" (ger., retail version)—to determine the initial game title list for this study. Since game titles on this derived list were in German, we manually retrieved the according English and Japanese game titles

from nintendo.com and nintendo.co.jp, respectively, as we needed those titles for a consecutive data retrieval from amazon.com and amazon.co.jp. Out of the 460 games, we only found according English and Japanese titles on nintendo.com and nintendo.co.jp for 251 games. (We eliminated the remaining 209 titles.)

The next step was deriving data from Amazon. We inserted the 251 games' according German, English, and Japanese titles into the search bars of amazon.de, amazon.com, and amazon.co.jp, respectively. From the obtained Amazon-results lists, we decided to select only one entry per website-version for analysis. Out of the 251 games, we eliminated 55 games because we did not find at least one *available* entry of their *physical version* on all three Amazon-website versions' obtained results lists. This means that for the remaining 196 games, we found at least one *available* Amazon-entry of their *physical version* on each of the three Amazon-website versions' obtained results lists.

When selecting one entry for each of the 196 games from the obtained results lists, we decided to prefer entries with the *local age rating*—i.e., the age rating system USK for entries on amazon.de [58], ESRB or PEGI on amazon.com [59–61], and CERO on amazon.co.jp [62]. We further preferred entries *dispatched from or sold by Amazon* over third-party accounts, and entries listed as *Amazon's Choice* [63]. A product is labelled as an *Amazon's Choice*-product on Amazon if it has a good ranking position determined by reviews and store purchases. The Amazon's Choice program operates on algorithms [63]. Kexel et al. [63] further describe Amazon's Choice as a "desirable" label, and they point out that marketers "must aim for high ranks and the desirable Amazon's Choice label" (p. 45) and that Amazon's Alexa will predominantly recommend Amazon's Choice products.

If two or more entries in a results list were marked with the *local age rating* and were also *dispatched from or sold by Amazon* and were included in *Amazon's Choice*, we selected the entry with the *highest number of Amazon-ratings*. If two or more entries also happened to have the same *number of Amazon-ratings*, we simply picked the entry *listed first* in the results. Using this preference order [24], we selected a total of 588 entries (i.e., 196 entries from each of the three Amazon-website versions) from the obtained results lists, and retrieved each entry's *number of Amazon-ratings* and *Amazon-rating score*.

For the 196 games, we retrieved the *publisher name* and *developer name* from nintendo.de since we also used that site as the source for the initial games list. If we did not find a publisher name or developer name on nintendo.de, we retrieved those names from either nintendo.com, nintendo.co.jp, or the game's official website. In addition, we retrieved each of the 196 games' German, English, and Japanese release date from nintendo.de, nintendo.com, and nintendo.co.jp, respectively. We thus manually retrieved data for this study from amazon.de, amazon.com, and amazon.co.jp, as well as from nintendo.de, nintendo.com, and nintendo.co.jp. The data was retrieved during the time period between December 7th and 24th, 2020.

In [64], we already introduced this methodology of a systematically set preference order for the choice of entries in an obtained Amazon results lists. That study discusses specific numerical results and rankings of an exemplary data retrieval. Its results reveal average Amazon-rating score rankings by *game genre*, as well as rank

comparisons of the three countries (i.e., Germany, U.S.A., and Japan). The focus was to provide an example of how heterogenous web data can be retrieved from global yet regionally tailored online platforms such as Amazon [64].

In [24], we showcase how such a data retrieval can incorporate a 3 × 3 criteria setting: Three attributes (i.e., we chose *genre*, *age rating*, and *player-count*), three forms of analysis (i.e., we chose *distribution*, *reception*, and *price*), and three countries (i.e., we chose Germany, the U.S.A., and Japan). In that study, we analysed rating, pricing, and age rating similarities and differences in those three countries. That study further focuses on possible effects the choice of certain online retail platforms such as Amazon can have on one's analysis results [24].

Other than in [64, 24], the contribution at hand discusses developer and publisher dominances as well as regional release date differences in the video game industry. In the following subchapter, we further introduce a systematically set requirements and preference order for the choice of Amazon-*review texts*, as well as a systematic category derivation for a manual sentiment analysis of review texts.

2.3 Data Retrieval for Review Text Analysis

Out of the final list of 196 games, the game genre *Action* has the most games assigned—a total of 96 games according to their nintendo.de-entry (it should be noted that most games on nintendo.de are assigned to more than one game genre) [64]. We considered a retrieval of review texts from more than one game genre, but eventually omitted it due to possible differences in review texts for games from different genres. By focusing on only one game genre, we avoid a mixing of regional differences and genre-specific differences.

2.3.1 Set Requirements and Preference Order for Choice of Review Texts

Amazon-review texts can be accessed by clicking on each Amazon entry's number of reviews. We conducted the retrieval of review texts on January 12th and 13th as well as on February 10th and 11th, 2021. Set requirements and a set preference order for the choice of review texts for the qualitative analysis are listed in Table 1.

Table 1 lists some requirements we set on the Amazon platform. Each chosen review text had to be marked as a *verified purchase* on Amazon, and their location had to state the required country (e.g., "Reviewed in Germany"). Each review text further had to be written for the software title's *Nintendo Switch* version (and not, e.g., the PlayStation 4 version) and for its *standard edition* (and not, e.g., a special edition). Table 1 further lists some requirements we set for the review texts. Each chosen review text had to have a 3-stars rating. Excluding spaces, each review text written in German and English had to contain more than 250 characters and less than 950 characters in order to be considered for this study. For Japanese review texts,

Table 1 Set requirements and preference order for choice of Amazon-review texts

Requirements & Preference order			Description
Requirement on **Amazon platform**	Verified purchase		Only review texts marked with "Verified Purchase" are considered
	Reviewed in Germany/the United States/Japan		Only review texts marked with "Reviewed in Germany"/"Reviewed in the United States"/"Reviewed in Japan" are considered
	Nintendo Switch version		Only review texts marked with "Platform: Nintendo Switch" are considered
	Standard edition		Only review texts marked with "Edition: Standard" are considered
Requirement for **review text**	3-stars rating		Only review texts with a 3-stars rating are considered
	250–950 characters/ 150–800 characters		Excluding spaces, only German and English review texts with 250 to 950 characters and Japanese review texts with 150 to 800 characters are considered
	Published up to December 2020		Only review texts published up to and including December 2020 are considered
Preference order	1	Most recent	Preference of review texts written on a later date (up to and including December 2020) to review texts with an earlier date
	2	Most helpful	Preference of review texts with the highest number of *people who 'found the review helpful'*

we set the required character count lower because compared to German or English, more can be expressed with less characters in the Japanese language. Thus, we limited each review text written in Japanese to 150 to 800 characters (excluding spaces). The reason for setting such criteria is that we assumed that 3-stars rated reviews as well as 'longer' review texts contain more constructive feedback compared to opposite pole-reviews (e.g., 1- and 5-stars rated reviews) or 'shorter' review texts (e.g., less than 250 characters for German review texts). We considered only review texts published up to and including December 2020.

Besides the set requirements, the set preference order listed in Table 1 states that we preferred review texts written on a date closer to the date of retrieval to earlier published review texts—i.e., *most recent*. We included this *most recent*-criteria to attain review texts published in a similar time frame, so that a game's chosen review texts' content aligned more when it comes to potential post-release updates and

provided additional content (i.e., DLCs). If two review texts were published on the same day (up to and including December 2020), we chose the review text with the higher number of *people who 'found this helpful'*—i.e., *most helpful*. We applied this *most helpful*-criteria only if two review texts were published on the same day. We placed it at the very bottom of the presented preference order to avoid a focus on the popularity of opinions.

2.3.2 Choice of Review Texts

The first review texts we considered were review texts written for *Action*-games that have the highest by number of ratings on their retrieved amazon.de-entries. For each chosen *Action*-game, we needed at least one acceptable review text (i.e., a review text that fulfils all set requirements presented in Table 1) for each of its three retrieved Amazon website version entries. We checked all three Amazon website version entries simultaneously for such acceptable review texts.

The *3-stars rating*-requirement (see Table 1) eliminated a large share of review texts from being considered for qualitative analysis. Manual checks revealed that in general, a very low percentage of the 288 retrieved entries' ratings were 3-stars ratings. (In particular, for *Action*-games with high numbers of ratings on amazon.de, Amazon usually displayed that only two to five percent of their ratings were 3-stars ratings.)

The *verified purchase*-requirement (see Table 1) also eliminated a noticeable proportion of review texts from being considered for the qualitative analysis. Furthermore, on amazon.com in particular, many review texts were eliminated from being considered since they were marked with "Reviewed in the United Kingdom" instead of "Reviewed in the United States"—the latter being a set requirement presented in Table 1.

Due to the strict set requirements (see Table 1), the highest-ranking *Action*-game by number of ratings on amazon.de—i.e., *Luigi's Mansion 3* with 6,907 ratings—only had four acceptable review texts found on its retrieved amazon.de-entry. Therefore, even though more than four acceptable review texts were found on its retrieved amazon.com- and amazon.co.jp-entry, we set the limit to four review texts for this game from each Amazon website version. These 12 review texts (i.e., four from amazon.de, four from amazon.com, and four from amazon.co.jp) written for *Luigi's Mansion 3* fulfil all set requirements listed in Table 1, and they were chosen according to the set preference order presented in Table 1.

The next step was to pick the *Action*-game with the next-highest number of ratings on amazon.de—i.e., *Super Mario 3D All-Stars* with 6,065 ratings—and to check for acceptable review texts on all three of its retrieved Amazon website version entries. Due to the strict requirements presented in Table 1, this game had no acceptable review text found on its retrieved amazon.com-entry. Therefore, even though we found acceptable review texts on its retrieved amazon.de- and amazon.co.jp-entry, we eliminated this game from being considered for the qualitative analysis. Besides *Super Mario 3D All-Stars*, the *Action*-games ranked third to seventh also did not have

at least one acceptable review text found on *each* of their three retrieved Amazon website version entries.

For the *Action*-game ranked eight by number of ratings on amazon.de, i.e., *Paper Mario: The Origami King* with 1,864 ratings, we found two acceptable review texts on its retrieved amazon.de-entry. Just like for *Luigi's Mansion 3*, even though we found more than two acceptable review texts for *Paper Mario: The Origami King* on its retrieved amazon.com- and amazon.co.jp-entry, we set the limit to two review texts for this game from each Amazon website version.

Then, we picked the next game in the ranking by number of ratings on amazon.de and checked for acceptable review texts on all three of its retrieved Amazon website version entries. We aborted this iterative selection of games and review texts as soon as 13 review texts were retrieved from each Amazon website version. Thus, we retrieved 39 review texts written for a total of seven *Action*-games for the qualitative analysis. Table 2 lists how many of those 39 review texts were written for which *Action*-game. Table 2 also lists each of the seven *Action*-games' total number of ratings on amazon.de as well as their according rank by number of ratings on amazon.de. The last game listed in Table 2 (i.e., *My Hero One's Justice* with 50 ratings) being on rank 59 out of 96 *Action*-games shows that even though 96 games were initially considered, a considerable number of those games (i.e., many games down to rank 59) had to be omitted due to the strict set requirements presented in Table 1.

For analysis, we translated any retrieved review texts written in German and Japanese into English. Since this study aims to uncover regional similarities and differences in customer feedback on selected games, we omitted a requirement that

Table 2 Distribution of number of retrieved review texts and according software title

Software title	Ratings on amazon.de		Number of retrieved review texts			
	Total number	Rank (out of 96 *Action*-games)	From amazon.de	From amazon.com	From amazon.co.jp	Total
Luigi's Mansion 3	6,907	1	4	4	4	12
Paper Mario: The Origami King	1,864	8	2	2	2	6
Astral Chain	407	17	2	2	2	6
Bloodstained: Ritual of the Night	121	40	2	2	2	6
LEGO DC Super-Villains	104	45	1	1	1	3
Fire Emblem Warriors	68	55	1	1	1	3
My Hero One's Justice	50	59	1	1	1	3
Total			13	13	13	39

limits the choice of review texts to the according local language of each Amazon website version—i.e., we did not limit this study's retrieval to, e.g., only German language review texts from amazon.de. As the customer could have simply typed their review text in English but might still be living in Germany, we decided that *language* was not a crucial factor for the linkage of Amazon-review texts to regions. Out of the 39 retrieved review texts, only one review text is written in a language other than the according Amazon website version's language—i.e., one of the 13 review texts retrieved from amazon.de is marked with "Reviewed in Germany" but is written in English.

Since natural language is ambiguous and its evaluation using computers is a tricky task [65], we showcase in the following a manual category derivation and assignment of review texts to categories.

2.3.3 Category Derivation

For the category derivation, we conducted a pre-survey on January 12th and 13th, 2021. From each of the three Amazon website versions, we retrieved three review texts—thus a total of nine review texts—for the game *Luigi's Mansion 3* according to the set requirements and preference order listed in Table 1. Then, we conducted a qualitative content analysis using the method described in the book by Mayring [66]. Since this study aims to compare the content of customer feedback from different regions, we used the approaches described by Mayring [66] and derived categories directly from the pre-survey's nine review texts. The categories were derived according to reoccurring topics in the nine review texts, i.e., text passages that talk about these topics. This way, a total of 36 categories were derived in the course of the pre-survey.

The aim of using categories in the presented study is to uncover content frequencies in review texts. As soon as a sentence, snippet, or term of a review text fit into a category, we assigned the whole review text to the respective category. We expected that an assignment of each review text to one or more categories uncovers certain patterns or tendencies. A generalization using categories derived directly from the review texts has the advantage that it does not use priorly defined theories, thus it can be regarded as free from the authors' presumptions [66].

However, we deemed an assignment of 39 review texts to 36 derived categories too in-depth for analysis. We concluded that uncovering content tendencies requires maintaining a certain overview of the review texts' content, and that an assignment of 39 review texts to 36 categories potentially leads to that overview being lost. Hence, we reduced the very number of categories, and additionally decided to provide some *overall interpretations* of the review texts to gain a broader sense of regional differences. Regarding the reduction of the number of categories, we merged some derived categories into broader categories so that the number was reduced from 36 to 12 categories. Categories were merged according to similarities of sentences, text snippets, or terms they were derived from. This study's 12 final categories are (1) *Economic (monetary) factor*, (2) *Genre*, (3) *Audio design*, (4) *Story*, (5) *Game characters*, (6)

Visual presentation, (7) *Author background information*, (8) *Game background information*, (9) *Game design*, (10) *Constructive feedback*, (11) *No constructive feedback*, and (12) *Sense of objective review and review structure.*

2.3.4 Category Description

The following is a description of the final 12 categories used in this study. The provision of a detailed category description caters to the traceability and comprehensibility of this study.

The category (1) *Economic (monetary) factor* marks text snippets in which, e.g., a review author mentions the game's price or whether they will keep, return, or resell the game. The category (2) *Genre* shows if a review text mentions any game genres. If a review author points out the game's music, voice over, or sound effects, the according review text was assigned to (3) *Audio design.* Likewise, if a review author mentions the game's story, the according review text was assigned to (4) *Story.* The category (5) *Game characters* marks review texts that mention game characters. It should be noted that although some text snippets contain the term "character"—e.g., "the stage is too narrow for such a poor character-controllability" and "the character doesn't jump or do more than walk around"—they were not assigned to (5) *Game characters* but instead to (9) *Game design* due to their context. The category (6) *Visual presentation* shows which review texts mention a game's visual design or cutscenes.

The category (7) *Author background information* marks review texts that contain background information about the author or their prior experiences with other games. This category serves to uncover how many of the reviewers include background information about themselves when writing their review. Text snippets assigned to this category can also indicate the reviewer's personal attachment to gaming or to a franchise, e.g., through experiences with past games in the same franchise.

Likewise, the category (8) *Game background information* marks review texts that directly or indirectly mention a game's publisher, developer, release date, age rating, target audience, and number of players.

The category (9) *Game design* is the widest spanning category in this study's qualitative analysis—i.e., the highest number of the initially derived 36 categories was assigned to this category. It contains review texts that mention a game's design in general as well as its playtime. It further marks review texts that mention a game's levels, boss fights and bosses, fights other than boss fights, enemies other than bosses, user interface, difficulty level, unlockable content, gameplay, controls, and in-game camera. If a review text talks about, e.g., enemies as in mentioning their fighting patterns, their 'intelligence' (i.e., how well they are programmed), or their presence, it was assigned to (9) *Game design.* However, if a review text talks about enemies as in mentioning, e.g., their appearance, background story, or personality, it was assigned to (5) *Game characters.*

Although the category (9) *Game design* contains a high variety, we refrained from splitting it up into further subcategories because many of its text snippets can be assigned to more than one subcategory. For example, the review text snippet "the

redo-checkpoints are quite far away" can be assigned to *game design* in general, as well as to *level design* and *difficulty design.* To name another example, "there is no reward even when proceeding with the story" can be assigned to *game design* in general, as well as to *unlockable content*. Some text snippets were found to be unclear or unprecise. For example, by "hectic gameplay", the review author might refer to *gameplay* in general, or to the game's *controls.* With text snippets such as "to prolong the gameplay" and "I beat the game in under 20 h of gameplay", the review authors rather referred to "playtime" than to "gameplay". Therefore, in order to keep overlaps low and to avoid misinterpretations of the review authors' statements, the category (9) *Game design* was not split up any further despite its high content variety. Since (9) *Game design* is the widest spanning category, we expected that most of the 39 review texts have some content that applies to this category.

The category (10) *Constructive feedback* marks text snippets that show the review author's openness for discussion. In such text snippets, the review author points out that the review is the current state of their assessment, but that that assessment might still change. This category also includes text snippets that can be regarded as a 'call for a civilized discussion'. In such text snippets, the review author, e.g., explicitly points out that this is their opinion. The category further includes an expression of regret or pity, as well as text snippets that give credit where credit is deserved. In the latter, the review author points out the game's good points besides its bad points. Since both positive and negative points are mentioned, such text snippets provide a sense of 'fairness' in a review text. The *constructive feedback*-category additionally includes text snippets that provide a sense of fairness by pointing out details to further describe any issues the review author has with the game. By including such text snippets, the review author does not simply dismiss the whole game as 'bad'. Lastly, the *constructive feedback*-category includes text snippets that provide 'cautious criticism'. This means that the review author uses certain terms to mitigate the strength of the statement.

The category (11) *No constructive feedback* marks text snippets with strong positive or negative emotional loading. Such text snippets result in the loss of a sense of constructive feedback. This category further marks text snippets with generally unclear expressions or feedback. It should be noted that a review text can be assigned to both (10) *Constructive feedback* and (11) *No constructive feedback* if it includes text snippets assigned to these two categories.

The category (12) *Sense of objective review and review structure* includes text snippets that provide a sense of 'objective' review or review structure. It marks text snippets written in a way as if the review author was writing for an official website or magazine. This includes the review author structuring their review text and listing positive and negative points. It also includes comparisons and a mentioning of factors which outweigh each other, as well as text snippets where the review author explicitly writes out the game's full name—again, as if they were writing a review for an official website or magazine. As soon as a text snippet had either a sense of objective review, a sense of review structure, or both, we assigned the according review text to this category. The difference between (10) *Constructive feedback* and (12) *Sense of objective review and review structure* is that (10) focuses on a review text's content

and marks texts that contain some valuable information in the form of feedback, while (12) merely marks review texts written in a 'formal' or structured way and that include comparisons.

We included the categories (1), (10), (11), and (12) to complement the otherwise game development-heavy focus of the derived categories. The reason for not including a category that marks review texts mentioning a game's *technical aspects* is because such a category rather depends on the chosen game itself than on regional differences. By analysing the 39 review texts, we found that as soon as a game has a technical issue on the Nintendo Switch, all of its retrieved review texts were addressing this issue—regardless of the region. For example, all six retrieved review texts for the game *Bloodstained: Ritual of the Night* and all three retrieved review texts for *My Hero One's Justice* mention the same technical issues (i.e., performance issues in *Bloodstained: Ritual of the Night*, and slow loading times in *My Hero One's Justice*). A potential *technical aspects*-category would thus simply mark review texts of games that have some technical issue, and it would be independent from customer experiences in different regions. Since this study's qualitative analysis aims to uncover regional differences in customer feedback, we omitted such a *technical aspects*-category.

3 Results of Analyses by Publisher and Developer

3.1 Distribution Results

This section serves to answer the first research question of this study. In total, 54 publisher names were retrieved for the 196 games. Figure 1 shows the 18 publishers that have three or more games assigned.

The top-three publishers with the highest number of assigned games are *Nintendo*, *NIS*, and *Bandai Namco* which all have their headquarters located in Japan [31, 67, 68]. Besides publisher names, a total of 62 developer names were retrieved for the

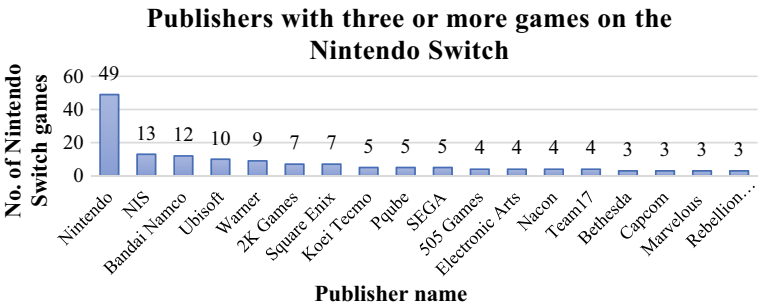


Fig. 1 Top-18 publishers on the Nintendo Switch by number of assigned games (out of 196 games)

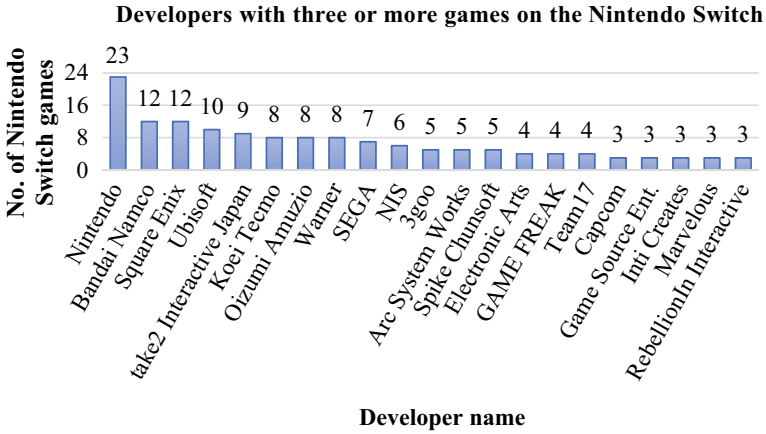


Fig. 2 Top-21 developers on the Nintendo Switch by number of assigned games (out of 196 games)

196 games. Figure 2 shows the 21 developers with three or more games assigned. Again, the top-three developers with the highest number of assigned games, i.e., *Nintendo*, *Bandai Namco*, and *Square Enix*, all have their headquarters located in Japan [31, 68, 69]. Out of the 196 games, 49 games have *Nintendo* listed as their publisher, and 23 games have *Nintendo* listed as their publisher as well as developer.

3.2 Results by Number of Amazon-Ratings

This section serves to answer the second and third research question of this study. In total, 127,563 ratings were retrieved from amazon.de, 287,683 ratings from amazon.com, and 114,049 ratings from amazon.co.jp. Figure 3 contains the top-five *games* by *absolute numbers of Amazon-ratings*. (The used software titles are those from nintendo.de and are thus presented in German.) The cell colour indicates the developer headquarter location: Yellow is Japan, blue is North America, and green is Europe. The majority of cells in Fig. 3 being coloured in yellow suggests an Amazon-rating number dominance of games by developers headquartered in Japan over developers headquartered in Europe (i.e., green cell; Ubisoft [70–72] 2021a, 2021b, 2021c) and North America (i.e., blue cells; Next Level Games, 2021).

To answer the third research question, Fig. 4 contains the top-five *publishers* and *developers* by *absolute* and *average numbers of Amazon-ratings*, as well as the publishers' and developers' headquarter locations. Green cells mark publishers and developers headquartered in Europe [71, 72, 74–76], blue cells mark a headquarter location in North America [73, 77–82], and yellow cells mark a headquarter location in Japan [31, 68, 69, 83–85].

Figure 4 suggests that—in contrast to the top-five *games* in Fig. 3—the lists of top-five *publishers* and *developers* by *absolute numbers of Amazon-ratings* are not

	amazon.de		amazon.com		amazon.co.jp	
	Software title	count	Software title	count	Software title	count
1	Animal Crossing: New Horizons	13,638	Animal Crossing: New Horizons	38,040	Animal Crossing: New Horizons	36,845
2	Luigi's Mansion 3	6,907	Just Dance 2020	15,806	Pokémon Schild/Schwert	7,597
3	Mario Kart 8 Deluxe	9,241	Luigi's Mansion 3	15,103	Splatoon 2	5,108
4	Pokémon Schild	5,857	Pokémon Schild/Schwert	12,040	Super Smash Bros. Ultimate	6,515
5	Super Mario 3D All-Stars	6,065	Super Mario Party	11,242	The Legend of Zelda: Breath of the Wild	4,843

Fig. 3 Top-five games by absolute numbers of Amazon-ratings. The cell colour indicates the developer headquarter location (yellow is Japan, blue is North America, green is Europe)

	Top-five by number of Amazon-ratings								
	amazon.de			amazon.com			amazon.co.jp		
	Name	Location	Count	Name	Location	Count	Name	Location	Count
	Publisher								
ab-solute	Nintendo	Japan	97,550	Nintendo	Japan	190,257	Nintendo	Japan	101,753
	Ubisoft	France	5,500	Ubisoft	France	24,597	Mojang	Sweden	2,429
	Mojang	Sweden	3,787	Warner	U.S.A.	13,623	Square Enix	Japan	1,461
	Warner	U.S.A.	3,393	2K Games	U.S.A.	10,647	Bandai Namco	Japan	1,420
	SEGA	Japan	3,077	Mojang	Sweden	10,051	Ubisoft	France	648
av-erage	Nintendo	Japan	1,991	Mojang	Sweden	5,026	Nintendo	Japan	2,077
	Mojang	Sweden	1,894	Nintendo	Japan	3,883	Mojang	Sweden	1,215
	CD PROJEKT RED	Poland	936	Ubisoft	France	2,460	CD PROJEKT RED	Poland	365
	Activision	U.S.A.	721	Activision	U.S.A.	2,445	Square Enix	Japan	209
	Blizzard Entertnmt.	U.S.A.	679	2K Games	U.S.A.	1,521	Koch Media	Austria	194
	Developer								
ab-solute	Nintendo	Japan	68,176	Nintendo	Japan	120,062	Nintendo	Japan	71,574
	GAME FREAK	Japan	13,877	GAME FREAK	Japan	33,092	GAME FREAK	Japan	18,308
	Next Level Games	Vancouver	6,907	Ubisoft	France	24,597	Square Enix	Japan	3,764
	Ubisoft	France	5,500	Next Level Games	Vancouver	15,103	Mojang	Sweden	2,429
	SEGA	Japan	3,933	Warner	U.S.A.	12,629	Imagineer	U.S.A.	2,145
av-erage	Next Level Games	Vancouver	6,907	Next Level Games	Vancouver	15,103	GAME FREAK	Japan	4,577
	GAME FREAK	Japan	3,469	GAME FREAK	Japan	8,273	Nintendo	Japan	3,112
	Nintendo	Japan	2,964	Nintendo	Japan	5,220	Next Level Games	Vancouver	1,539
	Mojang	Sweden	1,894	Mojang	Sweden	5,026	Mojang	Sweden	1,215
	Good-Feel	Japan	1,530	Ubisoft	France	2,460	Imagineer	U.S.A.	1,073

Fig. 4 Top-five publishers and developers by absolute and average numbers of Amazon-ratings. The cell colour indicates the developer headquarter location (yellow is Japan, blue is North America, green is Europe)

as strongly Japan-dominated. Instead, Fig. 4 unveils a joint dominance of publishers and developers headquartered in Europe (green cells), North America (blue cells), and Japan (yellow cells). These results align with these regions being dominant in the console game market [12–16].

Nintendo as a publisher and developer has the highest numbers of assigned games (see Fig. 1), thus it scores first by *absolute numbers of Amazon-ratings* by publisher and developer. *Nintendo* as a publisher also scores high by averages, and since it has by far the highest number of assigned games out of all publishers (see Fig. 1), it is therefore less likely due to outliers, but more likely that its games have genuinely garnered a strong rating resonance. This result underlines Nintendo's dominance as a publisher on its own Nintendo Switch console.

Unlike its dominance as a publisher, *Nintendo* as a developer does not score on top by *averages*. Instead, the developer *GAME FREAK* with its four assigned games (see Fig. 2) accumulates higher *average numbers of Amazon-ratings*. The developer *Next Level Games* also achieves very high ranks by averages. However, it has only one game assigned (i.e., *Luigi's Mansion 3*) with which it also manages to achieve high ranks by *absolute numbers of Amazon-ratings*. In a similar manner, the publisher and developer *Mojang* has only two games assigned (i.e., *Minecraft* and *Minecraft Dungeons*) and achieves high ranks not only by *averages*, but also by *absolute numbers of Amazon-ratings*.

4 Results of Release Date Analyses

4.1 Distribution Results

To answer the fourth research question of this study, this section shows the distribution of the 196 games by their three release dates retrieved from nintendo.de, nintendo.com, and nintendo.co.jp—both by release year and release month. Figure 5 shows the distribution of the 196 games by their release year. (One of the 196 games had its official Japanese release date set as *February 2021*. However, we still included that game in our study as it had acceptable entries found on all three Amazon-website versions.) Since the Nintendo Switch was released in March 2017 [86, 87], the earliest game releases date back to March 2017, as well. Figure 5 shows that there are no noticeable differences in the distribution of the 196 games by each release *year* between the three regions, but that there is a drop in releases in 2020 compared to 2019 and 2018. Figure 6 shows the distribution of the 196 games by release *month*, as well as an overall average distribution using data of all three regions. (We elaborate on potential explanations for the distributions in Figs. 5 and 6 in the Sect. 6.1.)

To visualize any deviations in the games' releases, Fig. 7 has each of the 196 games as a point on its x-axis, and a month-count on its y-axis. Since each year has 12 months, the y-axis goes from [1] *January 2017* to [60] *December 2021* (one of the 196 games has its official Japanese release date set in February *2021*). The games

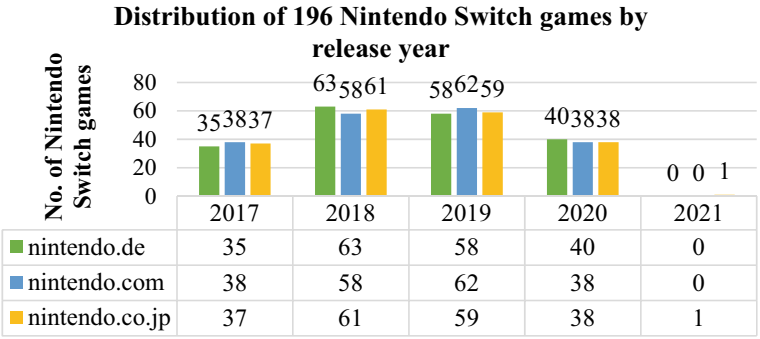


Fig. 5 Distribution of 196 Nintendo Switch games by release year

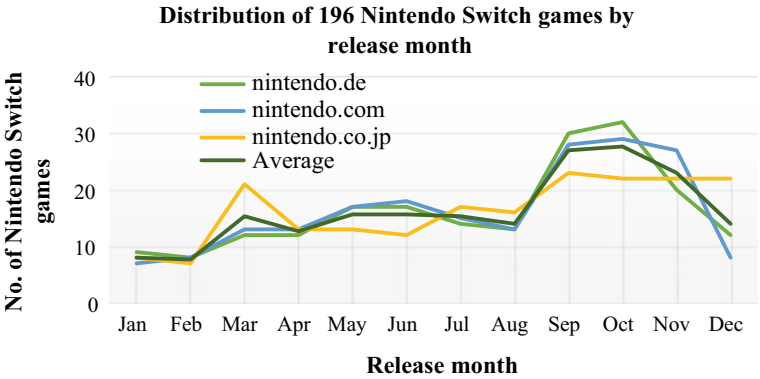


Fig. 6 Distribution of 196 Nintendo Switch games by release month

on the x-axis are ordered chronologically by their nintendo.de-release month which is why the green nintendo.de-curve is a steadily upward-going curve without any spikes. For each of the 196 x-points (i.e., each game), there are three points marked vertically on the y-axis (i.e., the according three regional release dates). 96 out of 196 games have the same release year and month retrieved from all three Nintendo-website versions. The remaining 100 games have partially different release months. 5 games have earlier release dates retrieved from nintendo.de than from nintendo.com or nintendo.co.jp. 8 games have earlier release dates retrieved from nintendo.com than from nintendo.de or nintendo.co.jp. And 34 games have earlier release dates retrieved from nintendo.co.jp than from nintendo.de or nintendo.com—which can be seen by the high number of yellow spikes deviating downwards on the y-axis (i.e., towards *earlier* dates), away from the green steadily upward-going nintendo.de-curve.

Based on Figs. 1 and 2, 8 shows the distribution of the 196 games by their nintendo.de-release year when dividing the games into the 49 games which are *published by Nintendo*, the 23 games which are *published and developed by Nintendo*

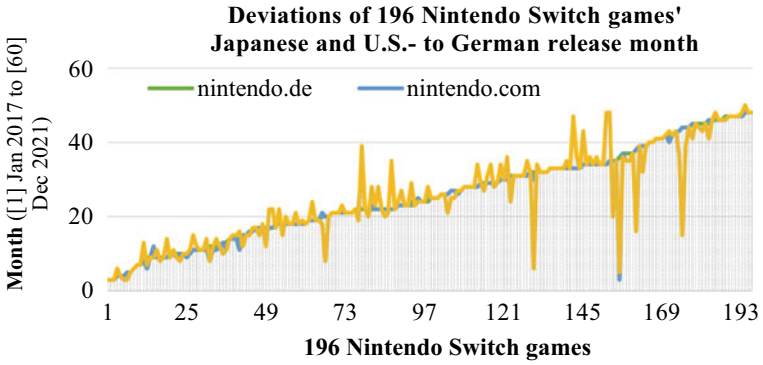
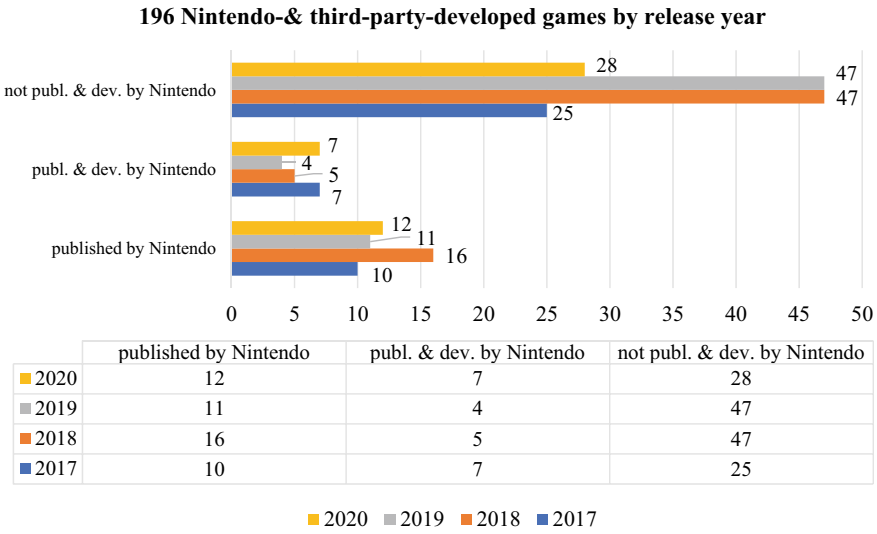


Fig. 7 Deviations of 196 Nintendo Switch games' Japanese and U.S. to German release months (ordered chronologically by German nintendo.de-release months)

(all of the 23 games which have *Nintendo* listed as developer also have *Nintendo* listed as publisher), and the 147 games which are *neither published nor developed by Nintendo*.



	published by Nintendo	publ. & dev. by Nintendo	not publ. & dev. by Nintendo
2020	12	7	28
2019	11	4	47
2018	16	5	47
2017	10	7	25

Fig. 8 196 Nintendo- and third-party-developed games by release year

4.2 Average Number of Amazon-Ratings and Average Amazon-Rating Score

This section serves to answer the fifth research question of this study. Figures 9 and 10 show the distribution of the 196 games' *average number of Amazon-ratings* by their release year and release month, respectively.

Figure 10 further shows a total average distribution using data from all three regions. This total *average number of Amazon-ratings* is 651 on amazon.de, 1,468 on amazon.com, and 582 on amazon.co.jp. March and October seeing such spikes in Fig. 10 happens to align with the spikes in the distribution by release month shown in Fig. 6. Most noticeable is the steep fall from January to February. February has a very low number of games released (see Fig. 6) and also scores low by *average numbers of Amazon*-ratings in Fig. 10. However, there are just as few games released in January as in February (see Fig. 6), yet January sees very high averages compared

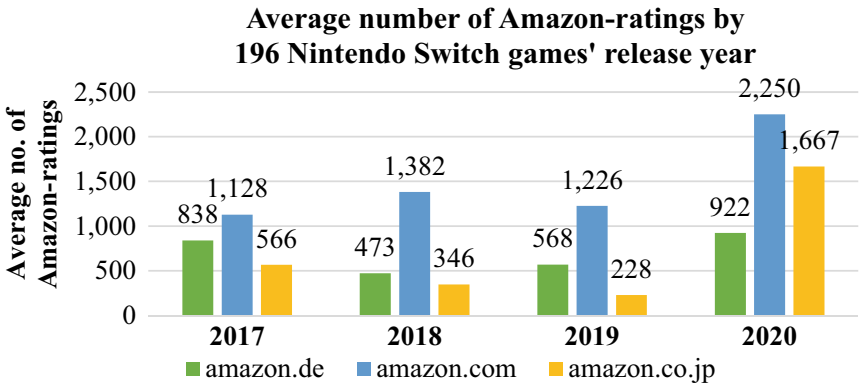


Fig. 9 Average number of Amazon-ratings by 196 Nintendo Switch games' release year

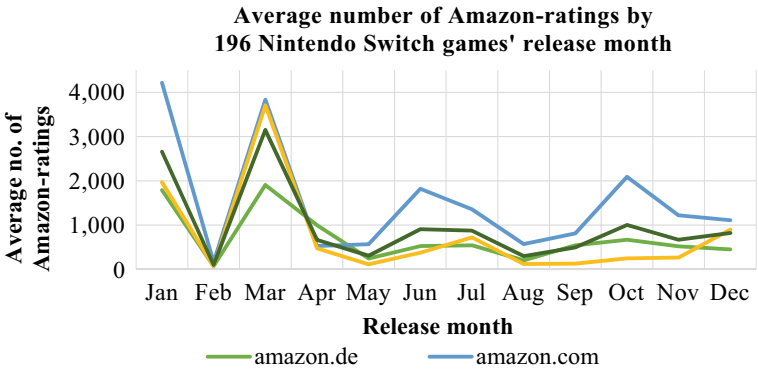


Fig. 10 Average number of Amazon-ratings by 196 Nintendo Switch games' release month

to February. (We name potential explanations for the distributions in Figs. 9 and 10 in the Sect. 6.2.)

The total *average Amazon-rating score* is 4.4 on amazon.de, 4.6 on amazon.com, and 4.0 on amazon.co.jp. Figure 11 shows the distribution of the 196 games' *average Amazon-rating score* by their release *year*. Although games released in 2020 score slightly better, there is overall hardly any difference in the scores between the four release years 2017 to 2020. All *average Amazon-rating scores* by release year are the highest on amazon.com and the lowest on amazon.co.jp. Figure 12 shows the distribution of the 196 games' *average Amazon-rating score* by their release *month.*

Figure 12 further contains a total average distribution using data of all three regions which overall shows that games released in January, March, and December accumulate the highest *average Amazon-rating scores.* In contrast to the noticeably high number of games having their release dates set in autumn and the pre-Christmas season (i.e., September to November or mid-December) in the U.S.A. and in Germany (see Fig. 6), the Amazon-rating scores retrieved from amazon.de and amazon.com are, on average, rather similarly distributed across all release months. On amazon.de, January and March score the highest by average rating scores, while February and April score the highest on amazon.co.jp. The distribution of

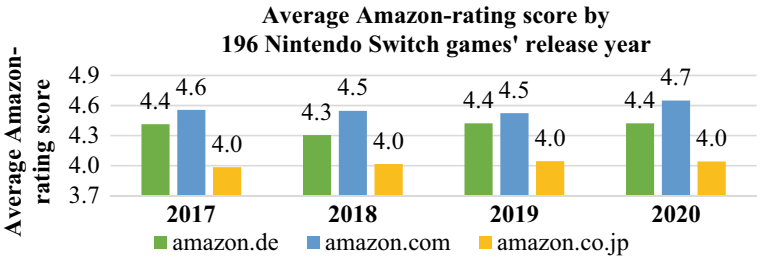


Fig. 11 Average Amazon-rating score by 196 Nintendo Switch games' release year

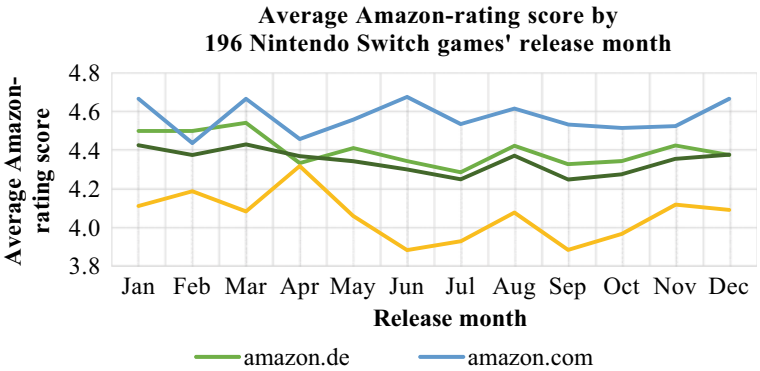


Fig. 12 Average Amazon-rating score by 196 Nintendo Switch games' release month

average amazon.com-rating scores by release months shows reoccurring spikes in the months January, March, June, and December. August sees spikes on all three Amazon-website versions.

5 Results of Manual Review Text Sentiment Analysis

5.1 Category Assignment

Tables 3, 4, and 5 contain the 12 derived categories and their numbering used in the presented qualitative analysis. Table 4 lists the results for the review texts numbered 1 to 20, while Table 5 lists the results for the review texts numbered 21 to 39. To ease gaining an overview of the assignment of review texts to categories presented in the tables, the tables show which of the 39 review texts contain sentences, snippets, or terms that fit into the 12 categories. As soon as a sentence, snippet, or term of a review text fit into a category, we marked the whole review text with an "X" in the respective category row. Table 3 shows the sum for each category, i.e., how many of the 39 review texts are assigned to each category.

5.2 Results and Interpretation of Category Assignment

This section serves to answer the sixth and last research question of this study. The goal of the presented qualitative analysis is to analyse to what extent review texts retrieved from amazon.de, amazon.com, and amazon.co.jp differ in terms of content. Due to differences in the categories themselves, we omitted comparisons across categories—the hereinafter presented results thus cover regional comparisons only within each category.

In the following, similarities and differences in the assignment of the 13 retrieved review texts per region to the 12 categories are presented. 35 of the 39 review texts contain one or more text snippets that mention the game's (9) *game design* in some way. Also, all 39 review texts have one or more text snippets that contain some sort of (10) *constructive feedback*. Since the categories (9) *Game design* and (10) *Constructive feedback* cover comparatively high numbers of subcategories (i.e., high numbers of the initially derived 36 categories) and therefore cover more content compared to other categories, these assignment results come as no surprise. All 39 review texts containing some sort of constructive feedback might stem from the set requirement that review texts have to contain a minimum number of characters (see Table 1). A set minimum number of characters heightens the possibility of a review author elaborating more thoroughly on their review, hence the possibility of the according review text to contain some sort of constructive feedback. Tables 4 and 5 also show that all review texts that contain a (12) *sense of objective review and*

Table 3 Number of assigned review texts (out of 13 per region) to each category

Category name		13 review texts from Amazon			Sum	Category name		13 review texts from Amazon			Sum
		.de	.com	.co.jp				.de	.com	.co.jp	
1	Economic (monetary) factor	5	5	4	**14**	7	Author background information	8	10	11	**29**
2	Genre	2	6	1	**9**	8	Game background information	7	8	7	**22**
3	Audio design	2	2	1	**5**	9	Game design	12	11	12	**35**
4	Story	1	5	7	**13**	10	Constructive feedback	13	13	13	**39**
5	Game characters	1	2	9	**12**	11	No constructive feedback	8	7	9	**24**
6	Visual presentation	7	5	3	**15**	12	Sense of objective review & review structure	9	5	8	**22**

Table 4 12 categories for qualitative analysis and assigned review texts (review texts numbered 1 to 20)

Source		amazon.de				amazon.com				amazon.co.jp				amazon.de		amazon.com		amazon.co.jp		amazon.de	
Review text no.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Economic (monetary) factor	X			X											X					X
2	Genre							X						X		X	X		X		X
3	Audio design					X						X									X
4	Story								X	X						X	X	X	X		
5	Game characters									X	X			X		X		X			
6	Visual presentation		X			X		X			X					X				X	X
7	Author background information	X		X		X	X	X	X	X	X	X	X	X		X	X		X	X	X
8	Game background information	X			X	X	X			X	X		X				X				
9	Game design	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	Constructive feedback	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	No constructive feedback					X		X		X			X	X	X	X		X	X	X	X

(continued)

Table 4 (continued)

Source		amazon.de				amazon.com				amazon.co.jp				amazon.de		amazon.com		amazon.co.jp		amazon.de	
12	Sense of objective review & review structure	X	X	X		X				X	X	X						X	X	X	X

Table 5 12 categories for qualitative analysis and assigned review texts (review texts numbered 21 to 39)

Source		amazon.com		amazon.co.jp		amazon.de		amazon.com		amazon.co.jp		.de	.com	.co.jp	.de	.com	.co.jp	.de	.com	.co.jp
Review text no.		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1	Economic (monetary) factor		X	X		X	X						X	X		X	X		X	X
2	Genre	X	X													X				
3	Audio design					X													X	
4	Story		X	X	X											X	X	X		X
5	Game characters			X	X				X	X				X			X			X
6	Visual presentation	X			X	X	X					X	X					X		X
7	Author background information	X	X	X			X	X		X	X	X		X	X	X	X			X
8	Game background information	X	X			X	X		X		X	X		X	X	X	X	X	X	X
9	Game design	X	X	X	X	X	X		X	X				X	X	X	X	X	X	X
10	Constructive feedback	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	No constructive feedback	X	X	X		X	X				X			X	X	X	X	X	X	X

(continued)

Table 5 (continued)

Source		amazon.com		amazon.co.jp		amazon.de		amazon.com		amazon.co.jp		.de	.com	.co.jp	.de	.com	.co.jp	.de	.com	.co.jp
12	Sense of objective review & review structure		X	X		X	X	X	X		X			X	X	X		X		

review structure also contain some (10) *constructive feedback*, but not vice versa. This is due to the set definitions of the categories (10) and (12) (see subchapter *2.3.4*).

Besides (9) *Game design* and (10) *Constructive feedback*, all three regions have similar numbers of review texts assigned to the categories (1) *Economic (monetary) factor*, (3) *Audio design*, (7) *Author background information*, (8) *Game background information*, and (11) *No constructive feedback*.

Apart from these similarities, we also found some differences—in particular in the assignment to the categories (2) *Genre*, (4) *Story*, (5) *Game characters*, (6) *Visual presentation*, and (12) *Sense of objective review and review structure*. Only three review texts retrieved from amazon.co.jp mention the game's *visual aspects* compared to seven and five review texts retrieved from amazon.de and amazon.com, respectively. Regarding amazon.com, only five review texts contain text snippets that indicate either a *sense of objective review*, a *sense of review structure*, or both—compared to nine and eight review texts retrieved from amazon.de and amazon.co.jp, respectively. Oppositely, six out of 13 review texts retrieved from amazon.com contain text snippets that mention a game's *genre* compared to only two and one review text retrieved from amazon.de and amazon.co.jp, respectively.

A noticeable pattern is that seven and nine review texts retrieved from amazon.co.jp contain some mentioning of the game's *story* and *characters*, respectively, and that those numbers are much lower for review texts retrieved from amazon.de and amazon.com. This aligns with literature pointing out Japanese customers' focus on characters [88], Japanese video games' unique character design [88, 89], and customers generally being drawn to Japanese video game characters [6, 90]. An underlying historical development alluding to a stronger story-focus can be shown by Japan even having its own RPG subgenre called JRPG [91–93]—the RPG genre is generally more story-focused compared to other game genres [94]. While Western RPGs have traditionally focused on player choice and immersion, Japanese RPGs were traditionally designed to have their focus on telling a specific story that is almost always starring predefined characters and little player customizability—as opposed to player-generated characters in Western RPGs [95, 96]. The link between JRPGs tending to provide engaging character development and narrative arcs [96] might be indirectly reflected in the Japanese customer feedback about the analysed games, and thus also in the assignment of review texts to categories.

5.3 Overall Interpretations of Review Texts

In order to avoid a sole focus on the category assignment itself, we present brief *overall interpretations* of the 13 review texts per region [66] in the following. However, since there can be some underlying issues that come with overall interpretations of texts—e.g., that such interpretations heavily depend on the interpreter—overall interpretations of review texts make up only a small part of the presented qualitative analysis. They are to be regarded as merely accompanying the results of the category assignments presented in the preceding Sect. 5.2.

Only three out of 39 review texts directly mention a game's age rating or target audience, and two of those three review texts are German. This comes as no surprise since Germany is known for its "more strict rules for video game content" [61], and it is said that "Germany has the strictest statutory rules in the world for the classification and sale of computer games" [97].

Another found difference is that the retrieved German review texts mention a game's developer less often than U.S.-American or Japanese review texts—i.e., only two texts retrieved from amazon.de compared to seven texts retrieved from amazon.com and four texts retrieved from amazon.co.jp.

Furthermore, two German and four Japanese review texts mention a game's difficulty level in some way—but no U.S.-American review text. Regional discrepancies in the mentioning of a game's difficulty might derive from games in the past being released in different regions with different difficulty levels. In particular, there have been instances of Nintendo games being made easier for the U.S.-American audience while the Japanese audience received those same games with their standard difficulty [92].

Regarding the overall tone, approximately half of the 13 review texts from each region are written in a rather casual manner, while the other half is written in a non-casual manner. The numbers of review texts that contain text snippets with a *lack of objective review* and that contain text snippets with a *lack of cautious criticism* are similar in all three regions. Compared to amazon.de and amazon.co.jp, a slightly lower number of texts retrieved from amazon.com contains text snippets with a *sense of objective review*. However, there are otherwise no noticeable differences between the 13 review texts per region when it comes to their overall tone.

6 Discussion of Release Date Results

Nintendo as a publisher and developer has the highest numbers of assigned games (see Figs. 1 and 2) which underlines its dominance on its own Nintendo Switch console. We did not consider an *average Amazon-rating score* since many publishers and developers had only one game assigned, thus a rating score provided by merely one user would have determined their rank. The same applies to any prices displayed on the Nintendo- and Amazon-websites. A noticeable trend during the data retrieval was that, when converted into Euro, displayed prices on the official Japanese Amazon- and Nintendo-websites were, on average, lower than on the U.S.-American or German websites, and that the German websites had the highest prices, on average.

6.1 Differences in Distribution

The distribution of the 196 games by release *year* (see Fig. 5) shows that the year 2017 had the lowest number of games released—highly likely due to the console's

low initial install-base after launch [98]. Since the console's software sales began to significantly rise in 2018 and continued to rise throughout 2019 and 2020 [86, 99–101], the years 2018 and 2019 in Fig. 5 see higher numbers of games released on the Nintendo Switch. However, despite a further increase in Nintendo Switch hardware and software sales in 2020, Fig. 5 shows that out of the selected 196 games, the share of games released in 2020 is noticeably lower than the share of games released in 2018 and 2019. A possible reason could be the outbreak of the Covid-19 pandemic impeding set 2020-release schedules. Nintendo might have had to reschedule game launches which were originally planned for the latter half of 2020 [99, 102–104].

The distribution of the 196 games by release *month* (see Fig. 6) shows some overall differences by release months, as well as differences between the three regions. Many of the 196 games have their release months set in autumn and the pre-Christmas season, i.e., September to November. The pre-Christmas season is traditionally a strong sales season for Nintendo [10, 33, 105, 106]. However, Fig. 6 shows that more of the 196 games have their release dates set in these months in the U.S.A. and Germany than in Japan. A reason for this might be that, in general, the focus on Christmas is not as strong for businesses in Japan as it is in the U.S.A. and Germany. Overall, the lowest numbers of games were released in January and February in all three regions. This could be linked to a lack of holidays in January and February in Germany, the U.S.A., and Japan, paired with the fact that Nintendo's fiscal year ends on March 31st [86, 99, 107]. (In general, businesses and government offices in Japan end their fiscal year at the end of March [108].) March again sees a spike in releases, particularly in Japan. A possible reason could be the amount of Japanese national holidays set in late April and early May [108, 109] which have many Japanese citizens take some vacation time to travel and—potentially—consume. The same applies to the months July and August in Japan [108, 109] which might explain the nintendo.co.jp-graph being slightly higher in those months, as well.

Regarding the deviations of the 196 games' Japanese and U.S.-American release months compared to their German release months (see Fig. 7), the blue curve having a low number of vertical spikes shows that only few games have noticeably different release months retrieved from nintendo.com (blue spikes) compared to the nintendo.de-curve. On the contrary, 34 out of 196 games having earlier release dates retrieved from nintendo.co.jp than from nintendo.de or nintendo.com aligns with some established industry practices of video game software—and hardware—being released in Japan first [10, 11]. However, since the distribution by release year is rather even across the three regions (see Fig. 5), such a delay of game releases in the West does not seem to cause any noticeable delays of releases into a subsequent release year in Germany or the U.S.A.

Compared to the video games market some 10 or 15 years ago, there are nowadays less differing release dates found for various regions. Whereas it used to be the norm to wait often times even over a year for, e.g., a Japanese game to get released outside of Japan (a possible contributing factor to that being lengthy localization procedures; cf. [1]), there has been a rising number of simultaneous worldwide releases in recent years in the gaming industry [110]—similar to the movie industry

[111]. Releasing simultaneously worldwide comes with its own challenges, though, as further elaborated on in [1].

A reason for the increasing number of worldwide releases is the so-called leakage of game projects or content. Risk of leakage might prompt developers to counteract by releasing games simultaneously worldwide instead of risking the occurrence of such leaks by leaving months between releases in different regions. Such leaks are problematic as they can contain so-called spoilers which are particularly problematic when selling story-heavy games (e.g., role-playing games) that are supposed to deliver surprises. These surprises can benefit from a simultaneous worldwide release and thus a simultaneous word-of-mouth-esque discussion (e.g., hashtag trending or spikes in comment numbers under a few videos) rather than applying the strategy of triggering such community developments in different regions in a drop-by-drop manner via belated release dates.

The differences in the distribution shown in Fig. 8 suggest that in particular third-party companies, i.e., companies other than the Nintendo company, were reluctant to release their games on the Nintendo Switch in its launch year 2017. This is shown by the category *not publ. & dev. by Nintendo* having a rather low number of games released in 2017 compared to its numbers in the subsequent years—with 2017 only having 25 games while 2018 and 2019 having 47 games released, respectively. A possible reason for this might be—besides the initially low install-base of the Nintendo Switch console in its launch year 2017 [98]—that there were initial difficulties with bringing third-party companies to develop for the newly launched console, as was the case with Nintendo's previous *Nintendo Wii U* home console. For the Nintendo Switch, however, Nintendo had increased its collaboration with third-party developers (such as Ubisoft, EA, Bethesda, Rockstar, Square Enix, Platinum Games, and Activision; cf. [98, 112]) which might explain the later increase in the number of games launched by third-party companies in 2018 and 2019. An underlying reason for the renewed decrease in 2020 in Fig. 8 might be the aforementioned Covid-19 pandemic impacting the 2020-release schedules [99, 102–104].

6.2 Differences in Rating Numbers and Rating Scores

Figure 9 shows that games released in 2020 have accumulated, on average, a noticeably high number of Amazon-ratings. The distribution in Fig. 9 suggests that games released in, e.g., 2017 have accumulated, on average, lower numbers of Amazon-ratings than games released in 2020, even though compared to the latter, the former had a longer time span until December 2020 (i.e., the month of data retrieval) to accumulate ratings. A possible explanation could be the Nintendo Switch having a higher cumulative number of hardware and software sold in 2020 than in the previous years [86, 99–101, 104], combined with a rather low number of games released in 2020 (see Fig. 5; [104]). Since 2020 had a higher cumulative number of Nintendo Switch owners but less new games to offer, the Nintendo Switch owners' attention might have shifted to fewer games when it comes to new releases (i.e., games released in

2020) compared to previous years. This might have led to each game released in 2020 experiencing, on average, more attention (i.e., receiving a higher number of ratings) than games released in the previous years. On amazon.co.jp in particular, the average number of Amazon-ratings for games released in 2020 is significantly higher than for games released in the previous years. This can be explained by the 2020-released game *Animal Crossing: New Horizons*. It has an extraordinarily high number of ratings retrieved from amazon.co.jp (36,845 ratings; see Fig. 3), and since 2020 has an overall low number of games released (see Fig. 5), 2020 achieves a high average number of ratings on amazon.co.jp.

Regarding release months, although there are just as few games released in January as in February (see Fig. 6), January sees very high averages in the *number of Amazon-ratings* compared to February (see Fig. 10). An explanation could be that besides the many games released in autumn and the pre-Christmas season (i.e., September to November or mid-December; see Fig. 6), games released in January are played similarly as much as games released in the pre-Christmas season. As a result, January sees a high *number of Amazon-ratings* (see Fig. 10) despite the comparatively low number of releases in January (see Fig. 6).

There being overall hardly any differences in *average Amazon-rating scores* between the four release years 2017 to 2020 (see Fig. 11) might be an indicator of an even distribution of games of 'similar quality' (i.e., similar rating scores) across the four years. This is particularly apparent on amazon.co.jp where games achieve roughly the same average rating score of 4.0 in all four release years (see Fig. 11).

7 Discussion of Review Text Results

7.1 Expectations Regarding Review Text Results

This study contains a qualitative analysis for selected Amazon-review texts to explore regional similarities and differences in customer feedback about video games in Germany, the U.S.A., and Japan. We expected a qualitative analysis of review texts to uncover some regional differences—e.g., that German review authors mention the *economic (monetary) factor* much more often, and that German review authors include more text snippets that have a *sense of fairness*. These expectations stem from literature describing Germans as "fair people" [113] and having a "'fair' balance between quality and price" [114].

Regarding Japanese review authors, we expected that they compare a game much more to its franchise or to past games. This expectation stems from long-term relationships being generally more common in Japan—not necessarily only among video game players, but in general, e.g., among businesses [114]. This expectation also stems from Japanese fans usually being described as 'loyal'—not only in regards to video games, since the loyalty of Japanese fans is also described in various literature for, e.g., rock music [115, 116], pop music [117–119], and baseball [120–122].

Contrary to the latter expectation even, we found the number of review authors who included comparisons to past games of the same franchise or to games from other franchises to be similar across all three regions.

We also expected that Japanese review authors in particular have noticeably different numbers of review texts that contain a *lack of objective review* and a *lack of cautious criticism* compared to German or U.S. American review authors. These expectations stem from Japanese people being described as having a "lack of social conflict" and often being seen by the West as being "afraid to get out of line" [123].

Expectations of finding more differences rather than similarities further derive from, e.g., the books by Toscano [124] and Hutchinson [89], the book chapter by Kitami et al. [18], and the study by Ćwil & Howe [125].

7.2 Potential Influence on Results by Similar Target Audience

A reason for the low number of uncovered differences—or rather for the high number of found similarities—might be that all seven games used for the qualitative analysis (see Table 2) are *Action*-games and thus have a similar target audience. It should further be noted that out of these seven *Action*-games, six games were developed by studios located in Japan [31, 68, 73, 126, 127]. Analysing almost only *Action*-games developed in Japan further alludes to a rather homogenous target audience.

Fan cultures surrounding Japan or the Japanese media in general have already been the focus of literature and past studies [6, 88, 128]. A similar target audience can result in more similarities and less differences being found in an analysis of according review texts. However, we deemed having a similar target audience an ideal prerequisite for a qualitative analysis in order to eliminate possible differences caused by games having different target audiences. Therefore, although the results are contrary to initial expectations, we deemed the high number of found similarities and the low number of found differences a satisfactory result for the qualitative analysis, and regarded the presented methodology as valuable for gaming industry research.

7.3 Potential Influence on Category Assignment

In the following, we discuss some critical notes regarding the category assignment. Although some text snippets such as those assigned to, e.g., the category (2) *Genre* are clearly distinguishable from text snippets assigned to, e.g., (3) *Audio design*, some other of the 12 categories have their definition or description set in such a way that parties other than this study's authors might have decided on a different assignment of text snippets to those categories. This is in particular the case for the four categories (9) *Game design*, (10) *Constructive feedback*, (11) *No constructive feedback*, and (12) *Sense of objective review & review structure*.

To counteract these notions, we created and saved detailed descriptions and listings of examples for the 12 categories as well as detailed listings of text snippets and their according category assignment. The Sect. 2.3.4 also serves to provide some first-step transparency and to ease the comprehension of the text snippet assignment and thus according review text assignment to categories. The assignment of review texts to categories is thus regarded as 'comprehensive enough' so that parties other than this study's authors can also agree upon or comprehend the assignment of a review text to, e.g., the category (10) *Constructive feedback*—i.e., whether a review text contains some 'constructive feedback'.

7.4 Potential Influence on Category Derivation and Overall Interpretations

Even though the category assignment was streamlined and its comprehension supported by the provision of descriptions and examples, the results of the presented qualitative analysis may still be subject to an underlying, unintended bias. This is due to the very derivation of categories itself which can be influenced by two factors.

The first factor is what in the analysis is perceived as 'not overarching enough' or rather 'too specific' to be a stand-alone category. When the number of categories was reduced from 36 to 12 in the course of a pre-survey, we decided that, e.g., controls, difficulty level, gameplay design, and fights are all part of the overarching *game design*-category. However, game developers or game magazine authors might have split up the categories differently, set for a different number of categories, or would have derived entirely different categories.

The second factor are underlying presumptions when deriving categories and when carrying out overall interpretations of the review texts. According to Mayring [66], an inductive category definition derives categories directly from the source texts in a generalisation process without referring to priorly formulated theory concepts. Although Mayring [66] mentions that such an inductive approach aims to depict the text material without distortion by the researcher's presumptions, such presumptions from the researcher might still be prevalent during the category derivation and overall interpretations of review texts.

For example, if the authors have a preconceived conception that Japanese customers in particular tend to be more reluctant to leave 'harsh' reviews and rather opt for writing cautious criticism, the authors might first derive a category called 'cautious criticism' and then retrospectively try to find text snippets that fit into this *cautious criticism*-category. Also, if the authors have a preconceived conception that, e.g., German reviewers tend to have a stronger sense of 'fairness' when writing their reviews, the authors might in the same manner first create a category called 'sense of 'fairness" and then select fitting text snippets for this category. When subsequently carrying out overall interpretations of the review texts, the authors might then also be

more likely to interpret German review texts as containing an overall sense of 'fairness'. In this manner, the authors' presumptions affect both the category derivation and overall interpretations of review texts.

Such involuntary preconceived conception can hardly be avoided. However, the reduction of the number of categories from 36 to 12 contributes to counteracting these presumptions' influence on the category assignment. For example, categories such as the initially derived *cautious criticism*- and *sense of 'fairness'*-categories were merged into a comprehensive *constructive feedback*-category to *(i)* lower the number of categories, and to *(ii)* make the assignment of a review text to the *constructive feedback*-category less prone to any bias.

Therefore, not only did we deem the assignment of review texts to categories 'comprehensive enough' (cf. Sect. 7.3), but we also deemed the final 12 categories per se 'distinguishable enough'. We argue that other parties are likely to agree upon whether to assign a review text to, e.g., the broader *constructive feedback*-category (i.e., whether a review text contains some constructive feedback in any way) or to more specific categories (e.g., a potential, more specific *cautious criticism*- or *sense of 'fairness'*-category).

Regarding the overall interpretation of review texts, further literature was included to counteract any potential bias. However, since the selection of literature also depends on the authors, some bias may still be prevalent in the presented qualitative analysis. It was nevertheless decided to carry out an inductive approach in the qualitative analysis and overall interpretations, and to explicitly address this potential bias. Additionally, explanations were given of where the authors' expectations regarding the qualitative analysis' results stem from (cf. Sect. 7.1).

7.5 Potential Influence on Results by Choice of Amazon

Besides a potential authors' bias, the very choice of analysing review texts from *Amazon*—or any other online platform—can influence what kind of review texts are obtained. This is mainly due to two reasons.

First, leaving a user rating or review text on any online platform voluntarily, i.e., without monetary compensation, requires the user to possess some level of commitment or dedication, or at least a strong reason (e.g., the existence of technical issues of a purchased product). This might already 'filter' the type of users and therefore the user experience to be analysed [24]. However, we deemed this reason independent from regions, i.e., that it affects users across all regions, so that we nevertheless used Amazon-review texts to uncover similarities and differences in user experiences across different regions.

Second, different game genres' target audience (e.g., users playing sports games compared to users playing text-heavy RPG games [24]) might have a differing level of reluctance or hesitation when it comes to leaving reviews for their purchased products on online platforms. However, we deemed this second reason independent from regions, i.e., that it affects target audiences across all regions. We also avoided

this second issue by choosing only review texts written for *Action*-games in order to equate the target audiences of the three regions.

8 Contribution and Limitations

Other than in [64, 24], in the contribution at hand, we analysed release dates because we deemed a systematic analysis of release dates in the video game industry a rare occurrence. Most sources that mention varying release dates in different countries either name single examples or aggregate developments or patterns based on year-long experience without any backup data. This study's contribution to video game release date development research is of value to practitioners and managers who are keen to understand underlying patterns or country-specific 'time-slots' within a year that are proven to be particularly successful—'success' as measured by Amazon-rating numbers and scores.

We used the *absolute number of Amazon-ratings* for a top-five games ranking because we interpreted it as an indication of the extent of a game's distribution or popularity (e.g., a game receiving 2,000 ratings on amazon.de but only 100 ratings on amazon.co.jp). Such data can provide information to scholars or industry insiders who want to gain an overview of the number of ratings certain games manage to accumulate on each of the three countries' Amazon-website version.

However, we did not include a top-five list of games by *average number of Amazon-ratings* nor by *average Amazon-rating score*, because both the number of ratings and the rating score face the same issues when being analysed by *averages*—that is, a potentially small denominator skewing the results.

Being aware of the drawbacks of rankings by averages, we nevertheless included an analysis of the *average number of Amazon-ratings* by publisher and developer for comparison's sake—with explicit mentioning of major outliers skewing the results. However, we omitted any analyses of publishers and developers by *average Amazon-rating score* because we found the top-average scores to be very similar due to many publishers and developers having only one game assigned. (In this study's dataset, e.g., 10 developers achieve an *average Amazon-rating score* of 5 on amazon.com because they have only one game assigned.) We regarded such an analysis as insufficiently informative.

Linking games' release dates to a 'snapshot' of their rating numbers and rating scores might be interpreted as a limitation of this study. The rating numbers and rating scores retrieved during a short time period between December 7th and 24th, 2020 may potentially differ if the data retrieval is performed during another season, e.g., during summer. However, this applies more to overall release years but less to release months over the course of the Nintendo Switch's life cycle. Since we accumulated the months' data for all months since the console's launch, we still regarded analyses by months as valuable sources of information for audiences who seek to learn about some release date patterns in the gaming industry across different regions.

Regarding review text analyses, our results can be useful for third parties such as game developer studios if the information they need is represented by the categories and regions we chose—e.g., if a developer studio wants to know which region's users tend to mention *game design* or leave more *constructive feedback* in their review text for an *Action*-game released physically on the Nintendo Switch.

It should be noted, however, that our study's results are by no means to be treated as being representative of the three regions, since we only analysed 39 review texts. Our study's methodology instead broadly serves as a contribution to the research of user experience in the video game industry. It is an example of how user experience data can be retrieved from global yet regionally tailored online platforms such as Amazon. It further demonstrates not only the data richness of Amazon but also the boundaries of review text content analyses. An uncovering of similarities and differences in the experiences with video games can be useful for a targeted catering to customers in different regions, and a continuation and expansion of such research can be of value to various industry players.

9 Conclusion and Future Research Directions

Based on retrieved Amazon-data of 196 Nintendo Switch games from three selected regions crucial for the gaming industry (i.e., Germany, the U.S.A., and Japan), our study's results confirm *Nintendo*'s dominance as a publisher and developer by number of released games on its own Nintendo Switch console. The retrieved data further shows some strong dominances of publishers and developers headquartered in Japan as they accumulate the highest numbers of games released on the Nintendo Switch. On all three Amazon-website versions, most of the top-five games by *absolute number of Amazon-ratings* are developed by studios headquartered in Japan. However, Japan's dominance is less apparent when ranking the top-five publishers and developers by *absolute* and *average numbers of Amazon-ratings.*

Analyses of 196 games by release date—retrieved from three regional Nintendo-websites—show that, independent from regions, the share of games released in 2020 is noticeably lower than in 2018 and 2019. There are similar trends in all three regions when it comes to release month distributions (e.g., January and February seeing significantly less games released than September and October). Although the majority of the analysed games was released in a similar time window in all three regions, we find a noticeable share of games being released in Japan first. The retrieved data also suggests that companies other than the Nintendo company, i.e., third-party companies, were reluctant to release their games on the Nintendo Switch in its launch year 2017.

In a broad sense, this study serves as an example for the possibilities and limitations when retrieving and analysing data from regional Amazon- and Nintendo-websites, and it can be used for future discourse about Japan's and Nintendo's dominance on the Nintendo Switch, as well as for future discourse about peculiarities and delays of Nintendo Switch software release dates.

Regarding review texts, we reveal different content and sentiments across the selected three countries by deriving a total of 12 categories and assigning text snippets, text sentences, or whole review texts to one or more of those categories. We term this method *manual sentiment analysis* of review texts. A future study analysing a higher number of review texts—or using another categorization rationale altogether—could lead to different results than those presented in this study. Furthermore, a future study could analyse review texts written for games from more than just one game genre and thus written by a more heterogenous target audience. By conducting such or similar additional research, this study's presented regional tendencies in user experiences with selected physically released Nintendo Switch games can either be confirmed or refuted—but in any case, expanded upon and analysed more thoroughly.

Lastly, when selecting review texts on the three Amazon website versions, there was a noticeable tendency of review texts written for games on amazon.de and amazon.co.jp to be slightly longer than those on amazon.com. This tendency could also be further explored in a future study.

References

1. Chandler, H.M., Deming, S.O.: The Game Localization Handbook, 2nd edn. Jones & Bartlett Learning, Sudbury, MA, USA (2012)
2. Norris, C.: Expectations denied: fan and industry conflict around the localisation of the Japanese video game Yakuza 3. Fibrecult. J. **23**, 73–94 (2014)
3. Mochizuki, T.: Sony Moves Playstation Headquarters to California. The Wall Street Journal, Tokyo (2016). www.wsj.com/articles/sony-moves-playstation-headquarters-to-california-1453794813#:~:text=SONY0.66%25saidTuesdaythat,mergewithSanMateo%2CCalif
4. David, E.: PlayStation's headquarters is moving to California with the newly created sony interactive entertainment. *silliconANGLE* (2016). www.siliconangle.com/2016/01/26/playstations-headquarters-is-moving-to-california-with-the-newly-created-sony-interactive-entertainment/
5. Consalvo, M.: Console video games and global corporations: creating a hybrid culture. New Media Soc. **8**(1), 117–137 (2006). https://doi.org/10.1177/1461444806059921
6. Consalvo, M.: Atari to Zelda. Japan's Videogames in Global Contexts. MIT Press, Cambridge, MA (2016)
7. Kunz, W.: Global Media Giants. (Birkinbine B.J., Gómez, R., Wasko, J., Eds.). Routledge, New York, London (2016). https://doi.org/10.4324/9781315682334
8. West, J.: How do the PS5 launch titles compare to PS4, PS3, PS2, and PlayStation? *gamesradar* (2020). www.gamesradar.com/how-do-the-ps5-launch-titles-compare-to-ps4-ps3-ps2-and-playstation/
9. Ozalp, H., Cennamo, C., Gawer, A.: Disruption in platform-based ecosystems. J. Manage. Stud. **55**(7), 1203–1241 (2018). https://doi.org/10.1111/joms.12351
10. White, J., Jones, D.: Nintendo Archives. Future Publishing, Bath (2016)
11. Harris, B.J.: Console Wars: Sega, Nintendo, and The Battle That Defined A Generation. HarperCollins, New York (2014)
12. Prato, G.D., Feijóo, C., Simon, J.P.: Innovations in the video game industry: changing global markets. Inf. Syst. Econ. eJ. 1–22 (2014)
13. Newzoo.: Top 25 public companies by game revenues—Q4 2019 (2020). www.newzoo.com/insights/rankings/top-25-companies-game-revenues. Accessed 13 April 2022

14. Ziesak, J., Barsch, T.: Analysis: how nintendo created a new market through the strategic innovation Wii. In: Barsch, T., Heupel, T., Trautmann H. (eds.), Die Blue-Ocean-Strategie in Theorie und Praxis. Diskurs und 16 Beispiele erfolgreicher Anwendung, pp. 299–326. Wiesbaden: Springer Gabler (2019)
15. Kim, J.Y., Kang, S.H.: Windows of opportunity, capability and catch-up: the Chinese game industry. J. Contemp. Asia **51**(1), 132–156 (2019). https://doi.org/10.1080/00472336.2019.1656761
16. Wada, T.: The core rigidity of Japanese home video game companies. Ann. Bus. Adm. Sci. **18**(5), 195–208 (2019). https://doi.org/10.7880/abas.0190921a
17. McAuley, J., Leskovec, J.: Hidden factors and hidden topics : understanding rating dimensions with review text. In: Proceedings of the 7th ACM Conference On Recommender Systems (RecSys), pp. 165–172. Hong Kong (2013)
18. Kitami, K., Saga, R., Matsumoto, K.: Comparison analysis of video game purchase factors between Japanese and American consumers. In: König, A., Dengel, A., Hinkelmann, K., Kise, K., Howlett, R.J., Jain, L.C. (eds.) Knowledge-Based and Intelligent Information and Engineering Systems, pp. 285–294. Springer, Berlin Heidelberg (2011)
19. De Prato, G., Feijóo, C., Simon, J.-P.: Innovations in the video game industry: changing global markets. Digiworld Econ. J. **94**(2), 17–38 (2014). www.ideas.repec.org/a/idt/journl/cs9401.html
20. Babb, J., Terry, N.: Comparing video game sales by gaming platform. Southwestern Econ Rev **40**(1), 25–46 (2013)
21. Babb, J., Terry, N., Dana, K.: The impact of platform on global video game sales. Int. Bus. & Econ. Res. J. **12**(10), 1273–1288 (2013). https://doi.org/10.19030/iber.v12i10.8136
22. Ziesak, J., Barsch, T.: Analysis: how nintendo created a new market through the strategic innovation Wii. In: Barsch, T., Heupel, T., Trautmann, H. (eds.) Die Blue-Ocean-Strategie in Theorie und Praxis. Diskurs und 16 Beispiele erfolgreicher Anwendung, pp. 299–326. Springer, Wiesbaden (2019). https://doi.org/10.1007/978-3-658-15480-6_20
23. Shay, R., Palomba, A.: First-party success or first-party failure? A case study on audience perceptions of the nintendo brand during the Wii U's product life cycle. Games Cult **15**(5), 475–500 (2020). https://doi.org/10.1177/1555412018813666
24. Boric, S., Strauss, C.: Systematic retrieval and analysis of heterogenous online retail platform data to support customer targeting in gaming business. In: Kryvinska, N., Greguš, M. (eds.) Developments in Information & Knowledge Management for Business Applications. Studies in Systems, Decision and Control, vol. 420, 4, pp. 479–504. Springer, Cham. https://doi.org/10.1007/978-3-030-95813-8_19
25. Sony Interactive Entertainment (2022) Home—corporate info— company profile. www.sie.com/en/corporate.html. Accessed 26 March 2022
26. Flower, J.: The Americanization of Sony. *WIRED* (1994). www.wired.com/1994/06/sony-2/
27. Ernst, D.: Evolutionary aspects: the Asian production networks of Japanese electronics firms. In: Borrus, M., Ernst, D., Haggard, S. (eds.) International Production Networks in Asia. Rivalry or Riches, p. 267. Routledge, New York (2000)
28. McHugh, P., Merli, G., William, W.A.: Beyond Business Process Reengineering: Towards the Holonic Enterprise. Wiley, Chichester (1997)
29. Kazuhiko, T.: The curse of "Japan, Inc." and Japan's microeconomic competitiveness. In: Funabashi, Y., Kushner, B. (eds.) Examining Japan's lost decades. Routledge, London (2015). https://doi.org/10.4324/9781315715223
30. Shaw, J., Onkvisit, S.: International Marketing: Analysis and Strategy. Routledge, New York (1989)
31. Nintendo.: Company information (2022). www.nintendo.co.jp/corporate/outline/index.html. Accessed 28 April 2022
32. Nintendo.: About Nintendo (2022). www.nintendo.com/about. Accessed 28 April 2022
33. Scheff, D.: Game Over: How Nintendo Conquered the World. Knopf Doubleday Publishing Group, New York (2011)

34. Kent, S.L.: The Ultimate History of Video Games: From Pong to Pokémon and Beyond—The Story Behind the Craze That Touched Our Lives and Changed the World. Three Rivers Press, New York (2010)
35. EXP.: 130 Jahre Nintendo. EXP special. Frankfurt am Main: Raptor Publishing (2020)
36. Amazon.: Hilfe und Kundenservice. Informationen für unsere Kunden in Österreich (2022). www.amazon.de/gp/help/customer/display.html?nodeId=201965900. Accessed 23 April 2022
37. Nintendo.: Datenschutzrichtlinie für die Benutzung der Website der Nintendo of Europe GmbH (2022). www.nintendo.at/Rechtliche-Informationen/Webseiten-und-My-Nintendo-Store-Datenschutzerklarung/Webseiten-und-My-Nintendo-Store-Datenschutzerklarung-637785.html. Accessed 23 April 2022
38. Nintendo.: Impressum—Betrieb der Website (2022). www.nintendo.ch/de/Hilfe/Impressum/Impressum-1106807.html. Accessed 13 May 2022
39. Crayton, R.J.: Self-Publishing Road Map. Seven Steps to Make Your Journey a Success. Ericella Press (2015)
40. Bauer, W., Kryvinska, N., Dorn, J.: Towards trust in digital services advertisements—buying experts' opinions on USDL-trust. CEUR Workshop Proc **2654**, 15–31 (2020)
41. Wang, X., Goh, D.H.L.: Components of game experience: an automatic text analysis of online reviews. Entertain Comput **33**, 1–7 (2020). https://doi.org/10.1016/j.entcom.2019.100338
42. Haque, T.U., Saber, N.N., Shah, F.M.: Sentiment analysis on large scale Amazon product reviews. In: 2018 IEEE International Conference on Innovative Research and Development (ICIRD 2018), pp. 1–6. IEEE, Bangkok (2018). https://doi.org/10.1109/ICIRD.2018.8376299
43. Brückner, S.: Play Across Cultural Borders: An Explorative Cross-Cultural Study of Digital Game Player Experience by Analyzing User Reviews and Think-Aloud Protocols. Doctoral thesis, Keio University, Japan (2020). www.koara.lib.keio.ac.jp/xoonips/modules/xoonips/download.php/KO90001001-20205390-0002.pdf?file_id=152105
44. Bork, O.: Gender & race in digital game cultures: a critical discourse analytical approach to metacritic game reviews. Master's thesis, Lund University, Sweden (2020). www.lup.lub.lu.se/student-papers/search/publication/9015407
45. Kasper, P., Koncar, P., Santos, T., Gütl, C.: On the role of score, genre and text in helpfulness of video game reviews on metacritic. In: 2019 Sixth International Conference on Social Networks Analysis, Management and Security (SNAMS), pp. 75–82. IEEE Xplore (2019). https://doi.org/10.1109/SNAMS.2019.8931866
46. Berg, J., Raddick, M.J.: First You get the money, then you get the reviews, then you get the internet comments: a quantitative examination of the relationship between critics, viewers, and box office success. Q. Rev. Film Video 34(2), 101–129 (2017). https://doi.org/10.1080/10509208.2016.1156426
47. Koehler, D.J.: Can journalistic "false balance" distort public perception of consensus in expert opinion? J. Exp. Psychol.: Appl. **22**(1), 24–38 (2016). https://doi.org/10.1037/xap0000073
48. Takatalo, J., Häkkinen, J., Kaistinen, J., Nyman, G.: Presence, involvement, and flow in digital games. In: Bernhaupt, R. (ed.) Evaluating User Experience in Games. Concepts and Methods, pp. 23–46. Springer, London
49. Koeffel, C., Hochleitner, W., Leitner, J., Haller, M., Geven, A., & Tscheligi, M. (2010). Using Heuristics to Evaluate the Overall User Experience of Video Games and Advanced Interaction Games. In R. Bernhaupt (Ed.), *Evaluating User Experience in Games. Concepts and Methods* (pp. 233–256). London: Springer.
50. Florig, D.: Studying American films through the internet. 미국학 (Migug Hak) **27**, 187–201 (2004)
51. Metacritic.: About metascores (2022). www.metacritic.com/about-metascores. Accessed 20 March 2022
52. Trimbur, J.: The Call to Write. Cengage Learning, Boston, Massachusetts (2014)
53. Johnson, D., Watling, C.N., Gardner, J., Nacke, L.E.: The edge of glory: the relationship between metacritic scores and player experience. In: CHI PLAY 2014—Proceedings of the 2014 Annual Symposium on Computer-Human Interaction in Play, pp. 141–150. Toronto (2014). https://doi.org/10.1145/2658537.2658694

54. Strråt, B., Verhagen, H.: Using user created game reviews for sentiment analysis: a method for researching user attitudes. In: 1st Workshop on Games-Human Interaction (GHITALY17), vol. 1956, pp. 1–6. Cagliari, Italy (2017). www.ceur-ws.org/Vol-1956/GHItaly17_paper_01.pdf
55. Isbister, K., Schaffer, N.: Game Usability: Advancing the Player Experience. CRC Press/Taylor & Francis, Boca Raton, FL (2008)
56. Greenwood-Ericksen, H., Poorman, S.R., Papp, R.: On the validity of metacritic in assessing game value Eludamos. J. Comput. Game Cult. **7**(1), 101–127 (2013)
57. Robertson, J.: The problem with metacritic user reviews. *KeenGamer*. (2020). www.keengamer.com/articles/features/opinion-pieces/the-problem-with-metacritic-user-reviews
58. USK.: Age classification for games and apps. Games and apps in the IARC system. additional content information (2022). www.usk.de/en/home/age-classification-for-games-and-apps/games-and-apps-in-the-iarc-system. Accessed 3 March 2022
59. ESRB.: Ratings guide. Rating categories (2022). www.esrb.org/ratings-guide. Accessed 24 April 2022
60. PEGI.: PEGI homepage (2022). www.pegi.info. Accessed 20 April 2022
61. Egenfeldt-Nielsen, S., Smith, J.H., Tosca, S.P.: Understanding Video Games: The Essential Introduction. Routledge, New York (2016)
62. CERO. (2022). About CERO. www.cero.gr.jp/en/publics/index/3. Accessed 24 April 2022
63. Kexel, C.A., Osterloh, J., Hanel, C.: Smart home. A new marketing era. In: Thorhauer, Y., Kexel, C.A. (eds.) Facetten der Digitalisierung. Chancen und Herausforderungen für Mensch und Management, pp. 31–54. Springer, Wiesbaden (2020)
64. Boric, S., Strauss, C.: Exploiting heterogenous web data—a systematic approach on the example of nintendo switch games. In: Pardede E., Santiago, M.-I., Haghighi, P.D., Steinbauer, M., Khalil, I., Kotsis, G. (eds.) The 23rd International Conference on Information Integration and Web Intelligence (iiWAS2021), pp. 69–73. ACM, New York, NY, USA (2021). https://doi.org/10.1145/3487664.3487674
65. Bashir, M.F., Arshad, H., Javed, A.R., Kryvinska, N., Band, S.S.: Subjective answers evaluation using machine learning and natural language processing. IEEE Access **9**, 1–12 (2021). https://doi.org/10.1109/ACCESS.2021.3130902
66. Mayring, P.: Qualitative Inhaltsanalyse. Grundlagen und Techniken. Beltz, Weinheim (2010)
67. NIS.: Company profile (2022). www.nippon1.co.jp/company/company.html. Accessed 25 April 2022
68. Bandai Namco.: Company profile (2022). www.bandainamco.co.jp/about/profile.html. Accessed 28 Feb. 2022
69. Square Enix.: Corporate profile (2022). www.jp.square-enix.com/company/en/outline. Accessed 24 April 2022
70. Ubisoft.: Just Dance 2020 (2022a). www.ubisoft.com/en-gb/game/just-dance-2020 . Accessed 24 Feb. 2022
71. Ubisoft.: Paris (2022b). www.ubisoft.com/en-US/studio/paris.aspx. Accessed 24 March 2022
72. Ubisoft.: Ubisoft Wordwide HQ (2022c). www.ubisoft.com/en-US/office/worldwide-hq.aspx. Accessed 24 March 2022
73. Next Level Games.: Contact (2022). www.nextlevelgames.com/contact. Accessed 24 March 2022
74. Mojang.: Betriebsinformationen (2022). www.account.mojang.com/terms#company. Accessed 24 April 2022
75. CD PROJEKT RED.: Our history (2022). www.en.cdprojektred.com/our-history. Accessed 25 Feb. 2022
76. Koch Media: Niederlassungen (2022). www.kochmedia.com/de/company/offices. Accessed 24 March 2022
77. Warner.: Terms of use. B. Pre-Arbitration Notice of Disputes (2022). www.policies.warnerbros.com/terms/en-us/html/terms_en-us_1.2.0.html
78. 2K Games.: About us (2022). www.2k.com/en-US/about-us. Accessed 24 Jan. 2022

79. Activision.: Locations (2022). www.activisionblizzard.com/location. Accessed 24 March 2022
80. Blizzard Entertainment.: Blizzard Entertainment Inc. (2022). www.bloomberg.com/profile/company/0369125D:US. Accessed 24 Jan. 2022
81. Blizzard Entertainment.: Locations (2022). www.careers.blizzard.com/global/en/locations. Accessed 24 Jan. 2022
82. Imagineer.: Home (2022). www.disneyimaginations.com/?refPageViewId=616ae9ada37c0d5a. Accessed 24 Jan. 2022
83. GAME FREAK.: Contact—various inquiries (2022). www.gamefreak.co.jp/contact. Accessed 24 Jan. 2022
84. SEGA.: About us—Access (2022). www.sega.co.jp/company/access/index.html. Accessed 24 Jan. 2022
85. Good-Feel.: History (2022). www.good-feel.co.jp/en/history. Accessed 24 Jan. 2022
86. Nintendo.: Nintendo Co., Ltd. —annual report 2017 (2017). www.nintendo.co.jp/ir/pdf/2017/annual1703e.pdf. Accessed 28 March 2022
87. Nintendo.: Nintendo.com.au homepage—Nintendo Switch launches on 3rd March 2017! (2022). www.nintendo.com.au/nintendo-switch-launches-on-3rd-march-2017. Accessed 22 Feb. 2022
88. Lim, T.W.: Merlion And Mt. Fuji. The 50 Years of Singapore-Japan Relations. World Scientific Publishing, Singapore (2017)
89. Hutchinson, R.: Japanese Culture Through Videogames. Routledge, London (2019)
90. Lamerichs, N.: Embodied fantasy. The affective space of anime conventions. In: Reijnders, S., Zwaan, K., Duits, L. (eds.) The Ashgate Research Companion to Fan Cultures, pp. 263–274. Ashgate Publishing, Surrey, UK (2014)
91. Kamm, B.O.: Role-Playing Games of Japan. Transcultural Dynamics and Orderings. Springer Nature, Cham (2020)
92. Kohler, C.: Power-Up. How Japanese Video Games Gave the World an Extra Life. Courier Dover Publications, Mineola, New York (2016)
93. Summers, B.O.: Mother/EarthBound zero and the power of the naïve aesthetic: no crying until the Ending. In: Gibbons, W., Reale, S. (eds.) Music in the Role-Playing Game: Heroes & Harmonies, pp. 35–53. Routledge, New York (2020)
94. Bissell, T.: Extra Lives. Why Video Games Matter. Pantheon Books, New York (2010)
95. NFGMan.: Character Design for Mobile Devices (2006). Focal Press, Burlington, Massachusetts
96. Schules, D., Peterson, J., Picard, M.: 6 single-player computer role-playing games. In: Zagal, J.P., Deterding, S. (eds.) Role-Playing Game Studies: Transmedia Foundations, pp. 107–129. Routledge, New York (2018). www.routledge.com/Role-Playing-Game-Studies-Transmedia-Foundations/Deterding-%0AZagal/p/book/9781138638907
97. Secker, E.: German youth protection in games. Current challenges and new debates. In: Elmenreich, W., Schallegger, R.R., Schniz, F., Gabriel, S., Pölsterl, G., Ruge, W.B. (eds.) Savegame. Agency, Design, Engineering, pp. 281–288. Springer, Wiesbaden (2019)
98. Wagner, E.: A strategic audit of Nintendo Co., Ltd. Honors thesis, University of Nebraska-Lincoln, U.S.A (2019). www.digitalcommons.unl.edu/honorstheses/144
99. Nintendo.: Nintendo Co., Ltd. —annual report 2020 (2020). www.nintendo.co.jp/ir/pdf/2020/annual2003e.pdf. Accessed 28 March 2022
100. Nintendo.: Nintendo Co., Ltd. —annual report 2019 (2019). www.nintendo.co.jp/ir/pdf/2019/annual1903e.pdf. Accessed 26 Jan. 2022
101. Nintendo.: Nintendo Co., Ltd. —annual report 2018 (2018). www.nintendo.co.jp/ir/pdf/2018/annual1803e.pdf. Accessed 26 Jan. 2022
102. Cryer, H.: Nintendo likely to internally delay future games as a result of COVID-19. USGamer (2020). www.usgamer.net/articles/nintendo-covid-19-has-had-a-significant-impact
103. Khalid, A.: Nintendo warns the pandemic could delay future product launches. Quartz (2020). www.qz.com/1853406/nintendo-warns-the-pandemic-could-delay-future-product-launches

104. Nintendo.: Consolidated Financial Statements—Consolidated Results for the Years Ended March 31, 2020 and 2021. Kyoto (2021). www.nintendo.co.jp/ir/pdf/2021/210506e.pdf
105. Ryan, J.: Super Mario—How Nintendo conquered America. Portfolio/Penguin, New York (2011)
106. Loguidice, B., Barton, M.: Vintage game consoles: An inside look at Apple, Atari, Commodore, Nintendo, and the greatest gaming platforms of all time. Focal Press, Burlington, Massachusetts (2014)
107. Nintendo.: Corporate management policy briefing (2020). www.nintendo.co.jp/ir/pdf/2020/200916e.pdf. Accessed 16 April 2022
108. Nishiyama, K.: Doing Business with Japan—Successful Strategies for Intercultural Communication. University of Hawai'i Press, Honolulu, Hawai'i (2000)
109. Greene, M.: Japan—A Primary Source Cultural Guide. The Rosen Publishing Group, New York (2005)
110. Duldulao, A.: Monster hunter: transition to the West (2019). www.blogs.evergreen.edu/apop2019-aj/2019/06/02/monster-hunter-transition-to-the-west-2/. Accessed 3 May 2022
111. Meir, C.: The emergence of Pan-European film studios and its implications for co-production studies and policy. In: Hammett-Jamart, J., Mitric, P., Novrup Redvall E. (eds.) Palgrave European Film and Media Studies, pp. 121–136. Palgrave Macmillan, Cham (2018). https://doi.org/10.1007/978-3-319-97157-5_7
112. Stanwick, P., Stanwick, S.: International Management—A Stakeholder Approach. Edward Elgar Publishing, Cheltenham (2020)
113. Hambrett, L.: What I Know About Germans. 101 Observations. Überlin, Berlin (2013)
114. Kwon, H.K.: Fairness and Division of Labor in Market Societies. A Comparison of the U.S. and German Automotive Industries. Berghahn Books, New York (2004)
115. Keaveney, C.T.: Western Rock Artists, Madame Butterfly, and the Allure of Japan. Dancing in an Eastern Dream. Rowman & Littlefield, London (2020)
116. Stevens, C.S.: Buying intimacy. Proximity and exchange at a Japanese rock concert. In: Kelly, W. (ed.) Fanning the Flames. Fans and Consumer Culture in Contemporary Japan, pp. 59–78. State University of New York Press, New York (2004)
117. Jung, S.: Korean Masculinities and Transcultural Consumption. Yonsama, Rain, Oldboy, K-Pop Idols Title. Hong Kong University Press, Hong Kong (2011)
118. Yano, C.: Letters from the Heart. Negotiating fan-star relationship in Japanese popular music. In: Kelly, W. (ed.) Fanning the Flames. Fans and Consumer Culture in Contemporary Japan, pp. 41–58. State University of New York Press, New York (2004)
119. Kim, J.U.: Despite not being Johnny's. The cultural impact of TVXQ in the Japanese music industry. In: Choi, J.B., Maliangkay, R. (eds.) K-pop. The International Rise of the Korean Music Industry, pp. 66–80. Routledge, New York (2015)
120. Kelly, W.: Sense and sensibility at the Ballpark. What fans make of professional baseball in modern Japan (2004). In: Kelly, W. (ed.) Fanning the Flames. Fans and Consumer Culture in Contemporary Japan, pp. 79–106. State University of New York Press, New York
121. Guttmann, A., Thompson, L.: Japanese Sports. A History. University of Hawai'i Press, Honolulu (2001)
122. Fitts, R.K.: Remembering Japanese Baseball. An Oral History of the Game. Southern Illinois University Press, Carbondale, Illinois (2005)
123. Kerbo, H.R., McKinstry, J.A.: Who Rules Japan? The Inner Circles of Economic and Political Power. Greenwood Publishing Group, Westport, Connecticut (1995)
124. Toscano, A.A.: Video Games and American Culture. How Ideology Influences Virtual Worlds. Lexington Books, London (2020)
125. Ćwil, M., Howe, W.T.: Cross-cultural analysis of gamer identity: a comparison of the United States and Poland. Simul. Gaming **51**(6), 785–801 (2020). https://doi.org/10.1177/1046878120945735
126. ArtPlay.: About us (2022). www.artplay.co.jp/about. Accessed 24 Feb. 2022
127. PlatinumGames.: Access (2022). www.platinumgames.com/company/access. Accessed 24 Feb. 2022

128. Schaub, J.C.: Otaku evolution. Changing views of the fan-boy in Kon Satoshi's perfect Blue and Paprika. In: Lent, J.A., Fitzsimmons, L. (eds.) Asian Popular Culture. New, Hybrid, and Alternate Media, pp. 59–78. Lexington Books, Plymouth, UK (2013)

Lexical Norms in Business, Informal and Internet Communication

Zoriana Kunch, Oksana Mykytyuk, Liliia Kharchuk, and Myroslava Hnatyuk

Abstract The article analyzes the typical violations of the lexical norm in the student environment, which allows based on corpus and computational linguistics to improve existing and develop new mechanisms for tracking errors and eliminating them. The survey showed that the policy of linguicide and ethnocide introduced the use of modern youth, especially at the level of Internet communication, a primitive level of lexical literacy, removing from the active vocabulary synonyms, epithets, phrases, metaphors, and other language tools. The intellectual indifference of the students led to the widespread introduction of Russianisms, inappropriate borrowings, unmotivated repetitions and altered interlingual homonyms. The poll also showed that Ukrainian, Latin, and biblical phraseologies had ceased to appear in virtually all types of speech. The destruction of the Soviet system of dialect space led to the transition of several tokens into passive vocabulary, which is a matter of grave concern. Based on the proposed research methodology, approaches to improving computer programs are identified, aimed at the following aspects of the problem: (1) correcting lexical errors, (2) checking the appropriateness of the use of tokens, (3) offering lexical units to improve the text.

Keywords Lexical norm · Internet communication · Business communication · Informal communication · Normative check

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1 Introduction

One of the most important signs of speech culture is steadfast and steady compliance with norms at all speech levels. Long stay of Ukrainians under colonial oppression (over 400 prohibitions of the Ukrainian word and numeral repressions against the Ukrainian language system) led to numeral violations of lexical norms, which is being developed into the use of words in their proper lexical meanings, confusing the meanings of words-paronyms, wrong use of borrowed lexical units and insufficient application of synonyms, etc. Thus, the issue of searching for mechanisms to reveal the problem concerning compliance with the norms at the lexical level as well as the improvement of modern automated means for its elimination has actually arisen.

Let us observe that online-format communication is the sphere of priority, which draws attention in a modern scientific discourse. Researchers turn their attention to the fact that functioning of the Internet in all spheres of human vital activity affects the communicative peculiarities of society, predetermines the development of new communication forms, in turn, the change of a format and a way of communication transforms lingual units, causes the appearance of certain peculiarities in styles and genres.

Peculiarities of the evolution of main linguistic norms, in particular lexical, ascertaining beyond-the-language reasons of Ukrainian lexical norm distortion during the XX century are thoroughly explored in the monograph "Lexical norm: destruction, search, revival" [1]. In the context of our research, the conclusions made by Bralić [2] are very interesting. She states, that the Internet in our time–mass communication, which has never happened in human history, and the most important is for communication to take place, whereas we regulate a language in the most convenient way, in other words, it is possible and advisable to violate the norm for the sake of communication simplicity.

The conclusions of Yus [3], made in his research "An outline of some future research issues for Internet pragmatics" are also very valuable. His remark, that Internet-communication, which first became popular in the 1990s, has made significant progress nowadays, is due to be made. Pragmatics also tries to follow continual changes the modern technologies bring to our life. Now we have an opportunity to make certain well-founded prognoses regarding the problems of Internet-communication to comprehend the radical changes in the contemporary use of the world network. In another research, Yus [4] has mentioned: "practical interpretations are usually determined as such that appear from the intention to establish and maintain relationship and social relations, but not from the intention to convey sufficient information. Thus, they are not typical cases of communication, the final relevance of which is focused on the value of announced contents".

In the new communicative reality social panels have become a weighty tool, by means of which the global network users obtain additional opportunities in communication and spreading information. Tsoumou [5] is due to state that the communication through the mediation of the Internet has changed the world by involving millions

of people with similar and different sociolinguistic environments in communication and expressing their ideas.

Tsoumou [5] has analysed the speech acts in politically-oriented interactions in the "Facebook" social network. By applying Vaigand's taxonomy towards the set of data consisting of more than 265 147 words, he considers the whole Facebook interaction to be a set of communicative actions purposely taken by users. The results show, that any expression is a speech act, oriented towards a goal, and that any elocutionary force itself cannot exist without its perlocutionary effect. Every act of speech is perfect until both forces—elocutionary force and perlocutionary effect—are considered to be the integral parts of an expression.

In contemporary researches there is emphasised, that educated environment needs the experts, able to use a language correctly under any communicative situation [6], to follow lexical norms [7]. At the same time it is noticed, that just Internet-communication has become one of the reasons for a low level of speakers' literacy. Ashwini et al. [8] have emphasised, that the problem of the digital technology epoch consists in the fact that normative speech becomes more desirable than obligatory. Quite a few scientists state that some weakening of normative requirements in informal communication related to the sphere of Internet technologies is acceptable [9–11]. Akhmadgalieva and Sattarova [12] have mentioned that Internet users have indifferent attitude towards normative requirements because they can constantly see words containing mistakes and are being used to identifying them in distorted forms.

The works dedicated to the analysis of normative requirements during Internet-communication and in other conditions [2, 13–15] are valuable for tracing the regularities in the attitude of the Ukrainian youth towards the violation of lexical norms. For instance, in the experimental research by Vergeiner et al. [16], attention is focused on the notions teachers and students possess about lexical norms in the high education sphere of Austria. It has been learned, that the youth, studying a foreign language and possessing rich collocational experience, show the ability to create lexically perfect texts during unconstrained speech [17].

In the context of our research, the explorations, which consider different lexical meanings and their use in different genres and communicative situations, and in the different languages [18–22] are valuable. We have analysed the peculiarity of using neologisms [23, 24], paronyms [25, 26], synonyms [14], lexical borrowings, particularly anglisms [24, 27–30], therms [31, 32], jargon vocabulary [33], polysemantic words [34], expressively saturated lexical units [35], etiquette expressions [36, 37], etc.

A low level of speech culture, use of Russianisms, slang, jargon words, incorrect use of borrowed words, wrong construction of phrases and sentences—all of this can make the impression on a reader that an interlocutor does not deserve trust as a person of a low cultural and educational level. So the issue of compliance with normative requirements in different communicative situations needs further research and in context of the analysis of concrete exposures of such violations, and for the purpose of developing common approaches towards the ways of speech mistake elimination

at different communicative levels, and for creation of automated means to help in compliance with proper speech culture.

The object of our research is the lexical norm, which becomes apparent in different ways in official, unofficial and Internet-communication, pointing out the most important tendencies of language system codification. The subject of the research are the results of filling out the questionnaire by the students of the Lviv Polytechnic National University regarding their attitude to compliance with lexical norms depending on a communicative situation. It is important that the adapted material is territorially mixed, as the students come from different regions of Ukraine. That makes it possible to trace general regularities in compliance with lexical norms by the speakers of this age group.

The novelty of the work consists in the fact that, for the first time, the source base, related to all of the types of lexical norm violations, is involved. The students' discourse was reproduced at the level of official, unofficial and Internet-communication, which allows basic communicative levels to be enclosed.

The purpose of our research is to analyse communicative behaviour of the youth and to trace the dynamic of compliance with different types of lexical norms in different communicative situations on the basis of the results of the survey taken by students from different specialities regarding their attitude towards compliance with lexical norms in official, unofficial and Internet-communication, as well as to examine the opportunities for improvement of automated systems which control this norm depending on a type of communication (official, unofficial and Internet-communication) on the basis of the types of lexical norm violations revealed in the student environment.

2 Research Material and Methods

In the process of work on our sociolinguistic research, the method of sociological analysis was the primary to apply, besides the methods of filling out questionnaires, experiment, description, mathematical-statistical and immediate observation. We apply the use of authors' tables. The Fig. 1 demonstrates the methodology of our research schematically.

Our top priority task was to design a questionnaire, which contains a few questions of introductive character (specialty, age, gender, a year of study, a place of birth and a place of school study, the time of moving to Lviv, a language of teaching at school and a language of communication at home, etc.). The main part of the student environment questionnaire, consisting of 23 questions, is dedicated to the use of normative Ukrainian language vocabulary in different communicative situations. For respondent answers to be as precise as possible and truthfully reproduce the realities of a language lexical level in three spheres (the business and informal environment, as well as in Internet-communication), we consciously provided each question with its interpretation in the form of illustrative material. For example, to hear one out of the four suggested answers (1. Yes, always; 2. No, never; 3. Not always; 4. Sometimes)

Fig. 1 Research methodology

to the question "Do you prefer Ukrainian counterparts contrary to borrowed words?", we gave such illustrative variants: fragrant instead of aromatic; a bookgather instead of a library; a shortcoming, an error, a disadvantage instead of a defect; introduction instead of implementation, etc.).

The experimental part of the research was realised with the help of Google Forms by questioning 498 respondents aged between 17 and 21. Among them, 158 questioned students are male persons (31.7%) and 340—female persons (68.3%). Most of the respondents are the students in the first year 286 (57.4%), in the second year—149 (29.9%), in the third year—36 (7.2%), in the fourth year—24 (4.8%) and in fifth/sixth year—3 (0.6%). The participants of the questioning represent most of the Ukrainian regions. 452 persons (90.8%) speak Ukrainian at home, 16 persons (3.2%)—Russian, 13 persons (2.6%) speak both Ukrainian and Russian. Here is opportunely worth noticing, that the Ukrainian language is native for 482 students (97%), moreover, 488 out of them (98%) studied at schools with the Ukrainian language of teaching.

The next out-of-the-line stage of the research had, as the purpose, to systematise the base collected, to classify it and to describe by means of the structural (descriptive) method, whose main part is the comparative analysis. Comparativity of the questionnaire answers has allowed to reveal that youngsters follow lexical norms unequally. General statistics of the answers as well as the statistics of the answers to a certain question are taken into account while analysing the data of the survey. The methods of generalisation and induction have made the linguistic-statistical analysis of received results possible. Systematised data have allowed to reveal the lexical norm violation tendencies in the student environment at the level of business and unofficial communication as well as Internet-communication. The urgent need for communicative situations to become lexically normative directs the scientific community towards improving software content, particularly programme means. Accordingly, in this research there is emphasised the main tendencies of software products, which must suggest users a correct lexical unit, or point out inappropriate use of a word-form.

3 Results

We have carried out the analysis of the questionnaire results on the topic "My attitude towards compliance with lexical norms in different communicative situations" filled out by 498 students of the Lviv Polytechnic National University aged between 17 and 21 of different specialities (applied linguistics, foreign affairs, law, cybersecurity, software engineering, computer science, social support, accounting and taxation, architecture, journalism, psychology, etc.). Let us emphasise, that for a more precise understanding of the questions, the respondents were provided with an interpretation to each question in a form of concrete examples, for instance:

- Do you use Russianisms? ("вспіти" vs. Ukrainian "vstyhnuty" (to be on time), "бувший" vs. Ukrainian "kolyshnii" (former), "справка" vs. Ukrainian "dovidka" (a reference), "слідуючий" vs. Ukrainian "nastupnyi" (next), "без спросу" vs. Ukrainian "bez dozvolu" (without a permission), "брюки" vs. Ukrainian "shtany" (trousers), etc.).
- Do you use Latin aphorisms? (ахіллесова пята (Achilles' heel), перейти Рубікон (to cross Rubicon), нитка Аріадни (Ariadna's thread), etc.).
- Do you use lexical repetitions? (моя автобіографія (my autobiography), сувенір на згадку (a souvenir as a keepsake), у січні місяці (in January the month) etc.).
- Do you distinguish between paroxysms? (військовий (military)—воєнний (martial), їжа (food)—їда (meal), гривна (grivna)—гривня (hryvnia), адрес (testimonial)—адреса (address), інженерний (engineering)—інженерський (engineer's), ефектний (spectacular)—ефективний (effective), дощовий (rainy)—дощовитий (wet), духовий (brass)—духовний (spiritual)—душевний (sincere), etc.).

- Do you use an emotional vocabulary reinforced by the use of word-formation tools? (спатоньки/spatonky (go bye-bye), тутечки/tutechky (here-abouts), величенький/velycheznyi (huge), страшнющий/strashniushchyi (awful), малесенький/malesenkyi (tiny), голосочок/holosochok (faint voice), сестриця/sestrytsia (sis), etc.)

Such an approach not just facilitated the search for the answers to the questionnaire, but also provided the real situation regarding the compliance with lexical norms to be reflected more precisely. The generalised experimental data about the percentage ratio of the answers to the different questions in the questionnaire are shown in the Table 1.

3.1 Business Communication

Analysing the students' answers to the questions regarding compliance with lexical norms in business, informal and Internet-communication, we have discovered a substantial divergence of the attitude between students towards the use of certain lexical units in different communicative situations. The youth demonstrate the most responsible attitude towards compliance with lexical norms in business communication, which is shown on Fig. 2.

It is significant that only 7.2% of respondents have stated that they always use Russianisms in business communication versus 70.9% of those who have never let such lexical mistakes happen. Opposing to this, let us mention that in internet-communication and informal talks comparative figures are totally different: 11.2% use Russianisms always and 20.3% use them never in informal communication and 11.8% use Russianisms always and 23.5% use them never in internet-communication as we can see on Fig. 3.

Taking into account the fact that over a half of the respondents make the sort of the mentioned mistakes seldom or never, we suppose that the use of software able to recommend the application of proper words can significantly improve the situation regarding compliance with lexical norms.

The attitude of the youth towards the use of phraseology during formal communication is also interesting. Positive approach to the use of Ukrainian phraseological units has been shown only by 10.6% of the surveyed, but 44.4% have stated that they never use Ukrainian phraseology in formal communication. Even lower percentage of the respondents use popular Latin expressions (2.8%) and Biblical aphorisms (3.2%). We presume that there are two circumstances which caused such an attitude to phraseology: first, a low level of proper lexical knowledge, second, perception of business communication as a short exposition of ideas, that doesn't allow the use of phraseological units. We should emphasise that such an approach is wrong because phraseological units help messages to get to the point, make them exact and memorable even in formal communication so that their use is considered to be reasonable and important [38]. However the materials of our survey demonstrate disconsolate

Table 1 Percentage of lexical rules in different communicative situations

Norm	Business communication	Informal communication	Internet communication
Do you use Russianism? (вспіти, бувший, справка, слідуючий, без спросу, брюки etc.)?	Yes, always 7.2%	Yes, always 11.2%	Yes, always 11.8%
	No, never 70.9%	No, never 20.3%	No, never 23.5%
	Not always 10.4%	Not always 23.3%	Not always 22.9%
	Sometimes 11.5%	Sometimes 45.2%	Sometimes 41.8%
Do you prefer Ukrainian words over borrowed equivalents (запашний замість ароматний; книгозбірня замість бібліотека; вада, хиба, недолік замість дефект; впровадження замість імплементація etc.)?	Yes, always 35.8%	Yes, always 17.7%	Yes, always 17.3%
	No, never 14.5%	No, never 20.9%	No, never 21.9%
	Not always 0%	Not always 0%	Not always 0%
	Sometimes 49.7%	Sometimes 61.4%	Sometimes 60.8%
Do you use Ukrainian phraseology? (бити байдики, оббивати пороги, нема кебети etc.)?	Yes, always 10.6%	Yes, always 28.1%	Yes, always 20%
	No, never 44.4%	No, never 12.2%	No, never 20.3%
	Not always 26.3%	Not always 22.9%	Not always 22.7%
	Sometimes 18.7%	Sometimes 36.8%	Sometimes 36.9%
Do you use Latin aphorisms? (ахіллесова п'ята, перейти Рубікон, нитка Аріадни etc.)?	Yes, always 2.8%	Yes, always 5.6%	Yes, always 4.4%
	No, never 61.8%	No, never 43.6%	No, never 52.8%
	Not always 19.3%	Not always 22.5%	Not always 19.7%
	Sometimes 16.1%	Sometimes 28.3%	Sometimes 23.1%
Do you use biblical aphorisms? (юдин поцілунок, земля обітована, вмивати руки etc.)?	Yes, always 3.2%	Yes, always 5.6%	Yes, always 5.2%
	No, never 74.1%	No, never 46.6%	No, never 54.8%
	Not always 12.7%	No never 20.1%	Not always 18.9%
	Sometimes 10%	Sometimes 27.7%	Sometimes 21.1%
Do you use dialect words? (бульба, бараболя, вуйко, тітчаник, колежанка, шамчей тощо)?	Yes, always 5.6%	Yes, always 42.2%	Yes, always 34.3%
	No, never 62.2%	No, never 13.2%	No, never 19.5%
	Not always 17.1%	Not always 14.8%	Not always 17.3%
	Sometimes 15.1%	Sometimes 29.8%	Sometimes 28.9%
Do you use outdated words? (перст, єси etc.)?	Yes, always 3.2%	Yes, always 3%	Yes, always 3.4%
	No, never 82.7%	No, never 62%	No, never 68.5%
	Not always 8.8%	Not always 17.7%	Not always 14.6%
	Sometimes 5.2%	Sometimes 17.3%	Sometimes 13.5%
Do you use epithets? (блискучий, чудовий, сонцесяйний etc.)?	Yes, always 49.8%	Yes, always 65.9%	Yes, always 61.6%
	No, never 11%	No, never 2.8%	No, never 3.4%
	Not always 17.9%	Not always 14.1%	Not always 14.3%
	Sometimes 21.3%	Sometimes 17.2%	Sometimes 20.7%

(continued)

Table 1 (continued)

Norm	Business communication	Informal communication	Internet communication
Do you use lexical repetitions? (моя автобіографія, сувенір на згадку, у січні місяці etc.)?	Yes, always 3.8%	Yes, always 6.6%	Yes, always 6%
	No, never 62.8%	No, never 36.7%	No, never 43.2%
	Not always 15.1%	Not always 19.1%	Not always 20.5%
	Sometimes 18.3%	Sometimes 37.6%	Sometimes 30.3%
Do you use word parasites (ну, е-е, здається, значить, так би мовити, от, значить, а-а, типу etc.)?	Yes, always 17.7%	Yes, always 54%	Yes, always 44.4%
	No, never 30.1%	No, never 3.4%	No, never 9.2%
	Not always 21.9%	Not always 14.8%	Not always 18.7%
	Sometimes 30.3%	Sometimes 27.7%	Sometimes 27.7%
Do you use metaphors? (краплина щастя, золоте волосся, виє вітер etc.)?	Yes, always 11.6%	Yes, always 24.5%	Yes, always 20.9%
	No, never 43.9%	No, never 22.3%	No, never 27.1%
	Not always 23.3%	Not always 22.7%	Not always 21.9%
	Sometimes 21.2%	Sometimes 30.5%	Sometimes 30.1%
Do you use interlingual homonyms (цілу неділю ходив на пари (замість правильного тиждень), нагло себе поводив (правильно нахабно) etc.)?	Yes, always 5.6%	Yes, always 15.9%	Yes, always 15.5%
	No, never 55%	No, never 25.3%	No, never 28.1%
	Not always 21.5%	Not always 20.5%	Not always 19.1%
	Sometimes 17.9%	Sometimes 38.3%	Sometimes 37.3%
Do you distinguish between paronyms (військовий – воєнний, їжа – їда, гривна – гривня, адрес – адреса, інженерний – інженерський, ефектний – ефективний, дощовий – дощовитий, духовий – духовний – душевний etc.)?	No, never 7.8%	No, never 4.8%	No, never 4.8%
	Not always 23.3%	Not always 27.9%	Not always 27.3%
	Sometimes 7.8%	Sometimes 12.7%	Sometimes 14.1%
	Yes, always 61.1%	Yes, always 54.6%	Yes, always 53.8%
Do you use synonyms (неправильний, хибний, фальшивий; насмішка, глузування, глум, іронія etc.)?	Yes, always 58.4%	Yes, always 57.8%	Yes, always 58.4%
	No, never 5.4%	No, never 3.8%	No, never 4%
	Not always 17.5%	Not always 17.3%	Not always 17.5%
	Sometimes 18.7%	Sometimes 21.1%	Sometimes 20.1%
Do you use periphrases, it means you say Дочка Прометея (замість Леся Українка), Титан праці (замість Іван Франко), Кобзар (замість Тарас Шевченко) etc.)?	Yes, always 10.8%	Yes, always 7.6%	Yes, always 6.8%
	No, never 51%	No, never 55.6%	No, never 58.2%
	Not always 17.1%	Not always 16.1%	Not always 16.5%
	Sometimes 21.1%	Sometimes 20.7%	Sometimes 18.5%

(continued)

Table 1 (continued)

Norm	Business communication	Informal communication	Internet communication
Do you use emotional vocabulary that is reinforced by the use of word-formation tools (спатоньки, тутечки, величезний, страшнющий, малесенький, голосочок, сестриця etc.)?	Yes, always 11.4%	Yes, always 42%	Yes, always 39%
	No, never 53.2%	No, never 9.4%	No, never 13.9%
	Not always 18.1%	Not always 19.3%	Not always 17.5%
	Sometimes 17.3%	Sometimes 29.3%	Sometimes 29.6%
Do you use profanity?	Yes, always 2%	Yes, always 13.7%	Yes, always 14.7%
	No, never 89.6%	No, never 22.9%	No, always 26.9%
	Not always 3.8%	Not always 20.9%	Not always 19.7%
	Sometimes 4.6%	Sometimes 42.5%	Sometimes 38.7%
Do you use jargon, vulgarities? (комп (комп'ютер), тачка (машина), ляп (груба помилка), академка (академічна відпустка), кера (класний керівник), заліковка (залікова книжка) etc.)?	Yes, always 5.4%	Yes, always 43.2%	Yes, always 46%
	No, never 71.1%	No, never 7.4%	No, never 7.2%
	Not always 12.4%	Not always 19.1%	Not always 18.9%
	Sometimes 11.1%	Sometimes 30.3%	Sometimes 27.9%
Do you use slang: бакси (долари), кльово – добре, мікрий – малий etc.)?	Yes, always 2.6%	Yes, always 27.5%	Yes, always 27.3%
	No, never 76.5%	No, never 17.7%	No, never 19.3%
	Not always 12.7%	Not always 21.9%	Not always 21.1%
	Sometimes 8.2%	Sometimes 32.9%	Sometimes 32.3%
Do you use rude, abusive words as чорт візьми, холера ясна, дурепа, ідіот etc.?	Yes, always 2.2%	Yes, always 19.7%	Yes, always 18.5%
	No, never 84.7%	No, never 16.3%	No, never 20.1%
	Not always 6.5%	Not always 22.3%	Not always 23.5%
	Sometimes 6.6%	Sometimes 41.7%	Sometimes 37.9%
Do you use Ukrainian swear words as for example "щоб тебе качка копнула", "щоб тобі добре було", "бодай вам гарбуз отелився" etc.?	Yes, always 2.6%	Yes, always 21.5%	Yes, always 18.9%
	No, never 83.9%	No, never 24.3%	No, never 30.7%
	Not always 7.4%	Not always 18.9%	Not always 18.1%
	Sometimes 6%	Sometimes 35.3%	Sometimes 32.3%
Do you care about the culture of your speech?	Yes, always 82.6%	Yes, always 46%	Yes, always 46%
	No, never 1.4%	No, never 2%	No, never 3.4%
	Not always 9.8%	Not always 37.6%	Not always 33.9%
	Sometimes 6.2%	Sometimes 14.4%	Sometimes 16.7%

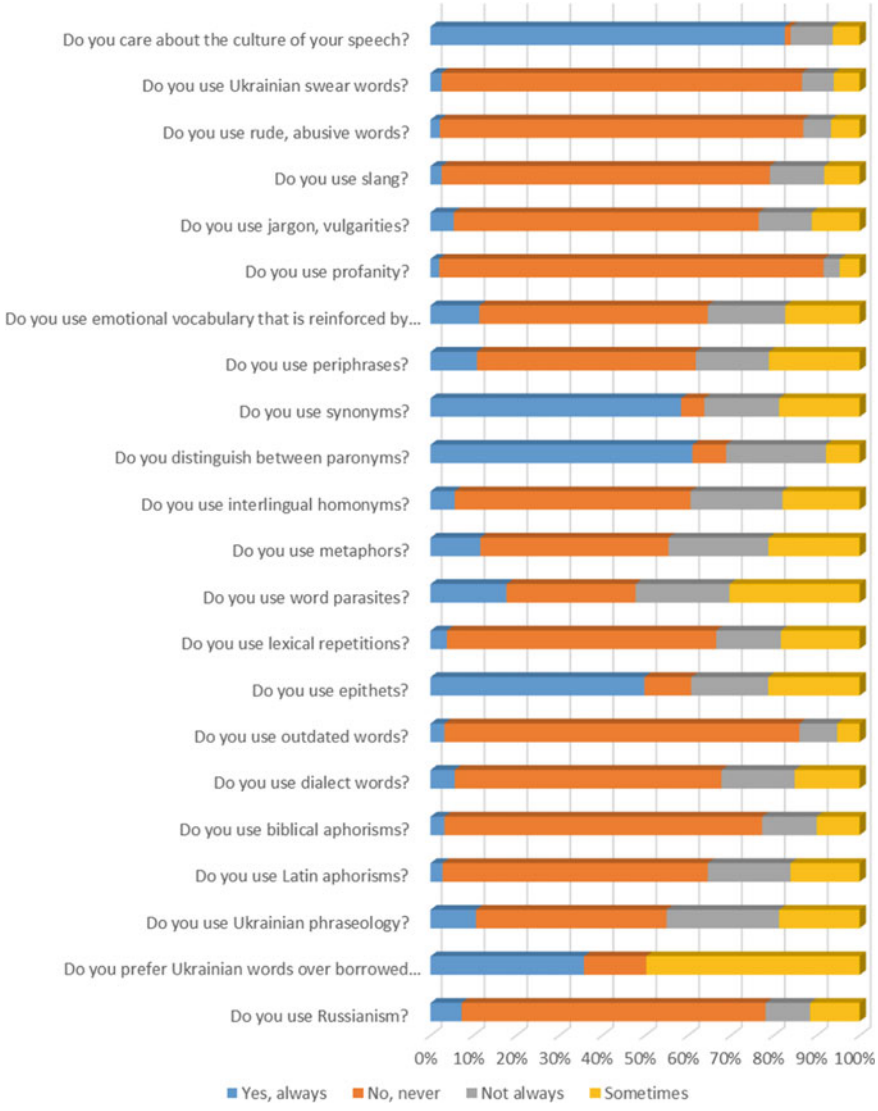

Fig. 2 Percentage of lexical rules compliance in the formal communication

statistics. 68.1% of respondents have stated that they never use Latin aphorisms in business communication, and 74.1% of respondents don't use Biblical expressions.

We may consider the youth survey result on their attitude to mistaken lexical repetitions, slang and swear lexicon to be positive because lexical repetitions are always avoided by 62.8% of the surveyed, slang is never admitted of by 71.1% and swear lexicon is not used by over 80% of those who participated in the survey.

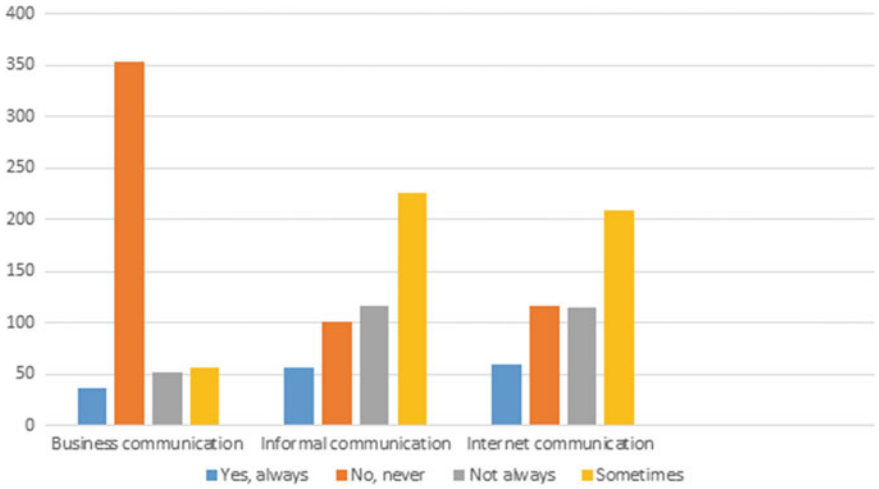

Fig. 3 Do you use Russianism (вспіти, бувший, справка, слідуючий, без спросу, брюки etc.)?

In general, it's important to emphasize that the modern educated youth are aware of the necessity of compliance with the requirements of speech culture in business communication. 82.6% have stated that they always care about speech culture in an official communicative situation, 9.8% have said that they do that not always, 6.2%—sometimes, and only 1.4% of respondents always ignore the rules of speech culture. It means that the university youth is interested in language norm problems, particularly at the lexical level, that provides the grounds to consider up-to-date software products prospective and facilitating compliance with norms.

3.2 Informal Communication

The analysis of the questionnaire data regarding informal communication indicates the presence of certain factors beyond the language, which cause noticeably more forbearing attitude towards compliance with lexical norms during informal communication. All of the indexes demonstrate a significantly lower level of compliance with the rules of applying different lexical units as the Fig. 4 shows.

The answers to particular questions demonstrate certain objective stylistic peculiarities, for example regarding the use of dialectical vocabulary or archaic words. Doubtlessly, under informal circumstances, speakers more often use dialectical vocabulary habitual in everyday verbal communication. The results of the survey shows that 42.2% of respondents always use dialectical words in informal communication, though contrary to that, in business communication, 62.2% of the students never use them. It's interesting to compare that in internet-communication the youth

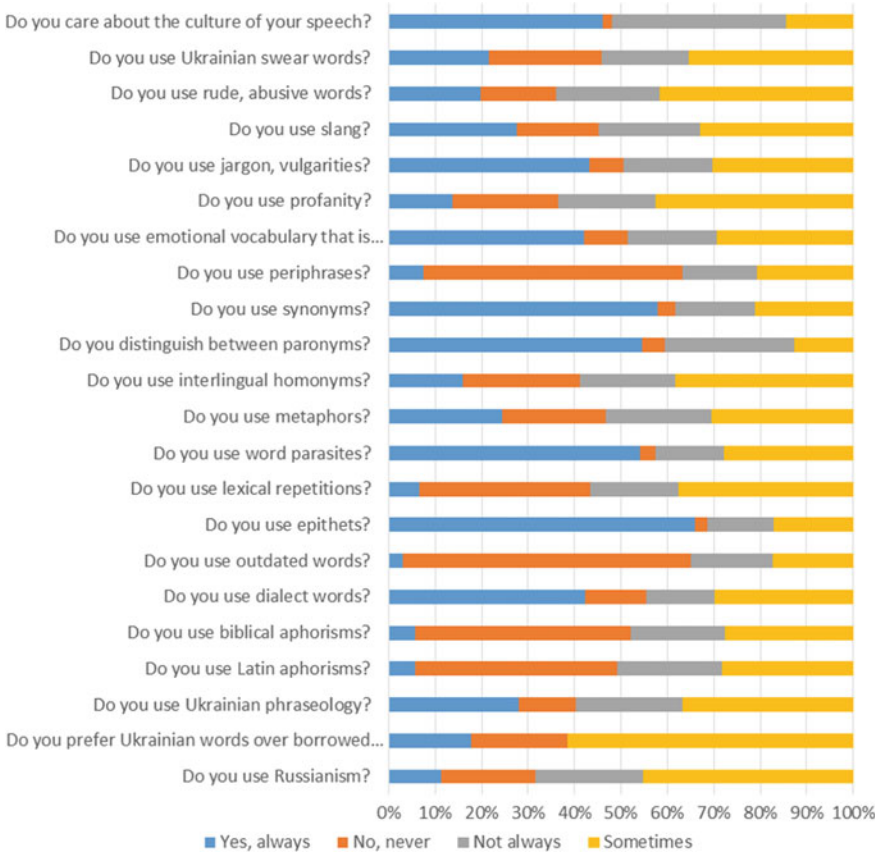

Fig. 4 Percentage of lexical rules compliance in the informal communication

are not fully aware of the stylistic role of dialectical vocabulary, that's why perhaps the answers to this question of the questionnaire are distributed relatively evenly: yes, always—34.3%; no, never—19.5%; not always—17.3%; sometimes—28.9%.

Archaic words, which can provide certain solemnity of an expression and give a specific stylistic effect under informal communicative circumstances [39], are always avoided by 62% of the surveyed, not always used by 17.7% of the respondents, by other 17.3%—sometimes, and always used by 3%. Meanwhile 82.7% of the respondents have stated that they never use archaic words in business communication, that just can be justified by the requirements of official-business style of the literary Ukrainian language as a restrained-neutral way to express an idea (see Fig. 5).

We have been observing a very interesting tendency for epithets, metaphors, periphrases or other stylistic means which provides expressiveness, exactness, emotionality of a say to be used under informal circumstances. 65.9% of the respondents have stated that they always use epithets (vs. 2.8% of those who never use them), 57.8% use Ukrainian synonyms (vs. 3.8% of those who never apply this

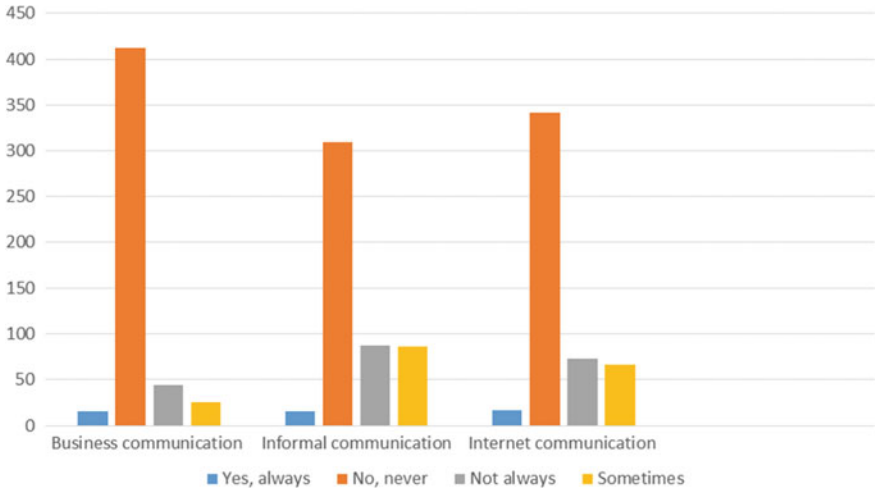

Fig. 5 Do you use outdated words? (*непсm*, *єсu* etc.)?

means), but the respondents haven't proved their favour towards the use of such artistic means as the metaphor (it is steadfastly used only by 24.5% of the surveyed) and the periphrase (they are applied only by 7.6% of the surveyed). We may presume that this situation can be partially caused by a low level of youth's active vocabulary, and also underestimation of expressive possibilities of tropes, though their use, as it is seen from scientific researches, furthers not just the vividness of speech, but also is one of the signs of language culture [39].

Besides, we've been noticing the aspiration for more active use of other means of self-expression in informal communication instead of figures and tropes. This is affirmed by the data of our research on the rate of using jargon, vulgarities, which appeal to 43.2% of respondents, rude, abusive words, which are steadfastly used in informal communication by 19.7% of students, Ukrainian swear words which are usually applied by 21.5% of the surveyed, slang, which is eagerly used by 27.5% of those who filled out the questionnaire. Even the profanity in informal communication is positively accepted by 13.7% of respondents, and other 20.9% use it not always and 42.5% sometimes. We have to mention that this tendency toward vulgarisation of speech in informal communication is traced at other language levels [1, 39, 40].

3.3 Internet Communication

The materials of our research show that the attitude of the youth towards the language norms at the lexical level during internet-communication coincides approximately with the data of the survey regarding informal communication (see Fig. 6).

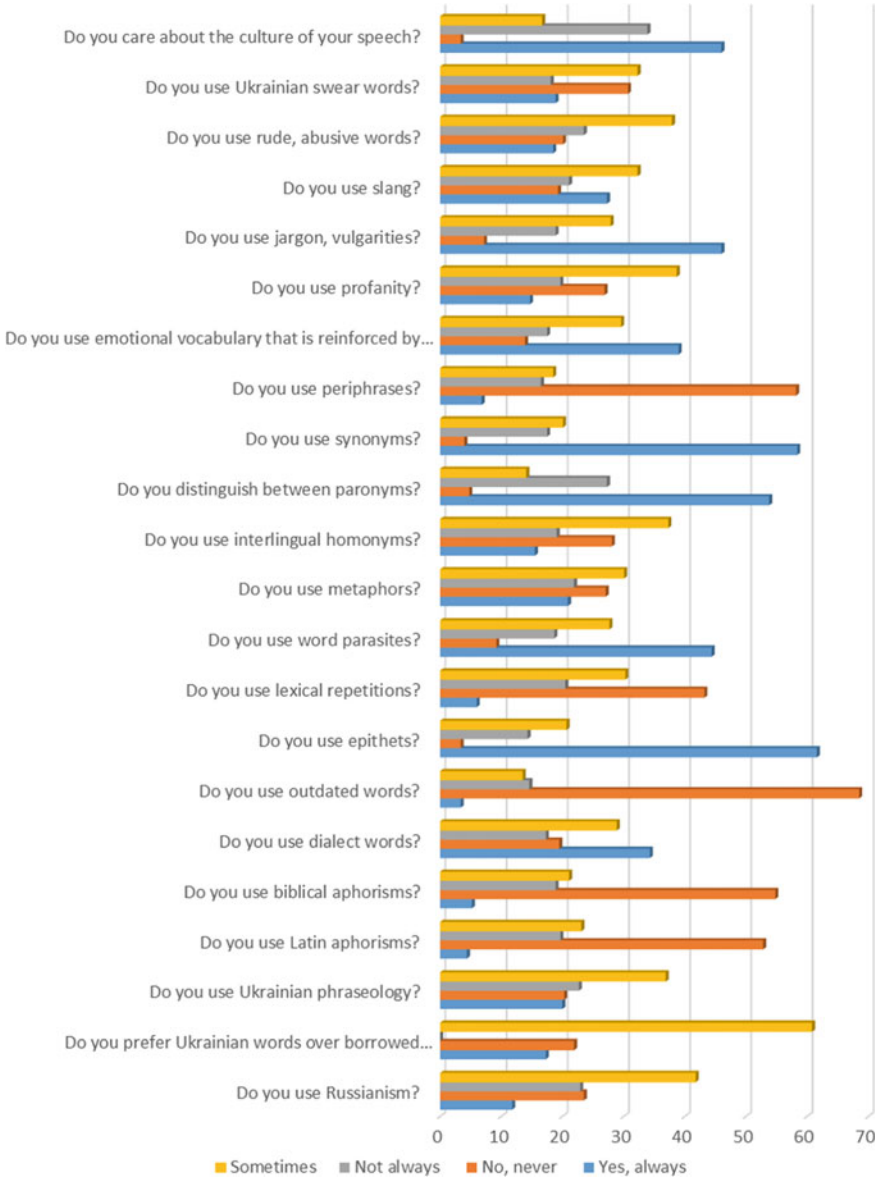

Fig. 6 Percentage of lexical rules compliance on the Internet

So the constant need to follow the norms of language culture during internet-communication as well as during informal communication is felt only by 46% of respondents. We consider these statistics to be disconsolate, because comments and messages located on different websites and social media are available for a long while, witnessing the language culture level of the communicating. This, respectively, affects a general image of a person, thus there is a practical need to change the situation in the direction of compliance with lexical norms.

The materials of our research, referring to the use of stylistically coloured lexic inherent in colloquial-casual level of communication, cause particular concerns because these indexes are somewhere even higher than the indexes in situations of informal communication. So 14.7% of the surveyed are inclined to regular use of the profanity in internet-communication, other 27.9% use it sometimes, and 18.9%—not always; 46% of respondents always use jargon and vulgarities, other 27.9% sometimes and 18.9% not always. The indexes of using slang have appeared to be a bit but not too much lower (27.3% vs. 27.5% in informal communication) and Ukrainian swear words (18.8% vs. 21.5% in informal communication). In general, we state the problem of a low level of compliance with lexical norms regarding this type of vocabulary, which actuates the necessity of using software for this purpose.

At the same time we have been observing a positive tendency about the use of synonyms in internet-communication. The data of the survey show that the youth apply this feature of our language approximately at the level of formal communication that is reflected on Fig. 7.

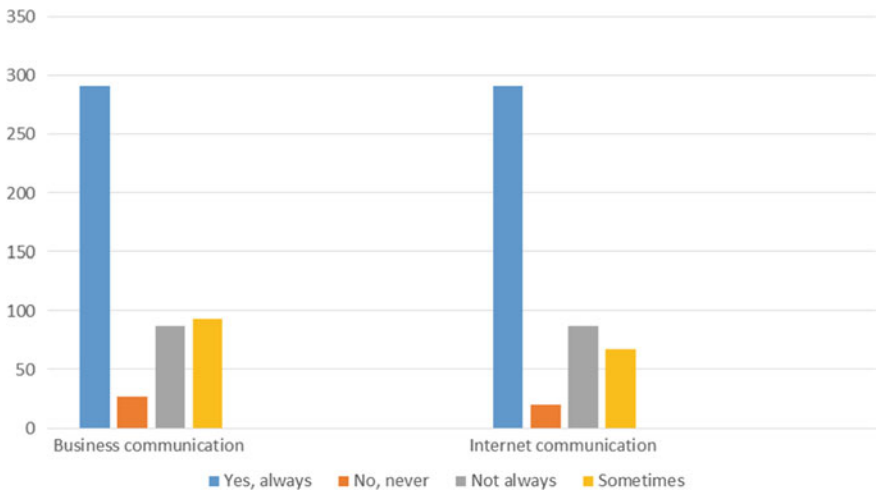

Fig. 7 Do you use synonyms (неправильний, хибний, фальшивий; насмішка, глузування, глум, іронія etc.)?

3.4 Percentage of Lexical Rules Compliance in Different Communication Situations

The comparative analysis of the survey data regarding three different communicative situations provides us with an opportunity to realise the differences in the attitude of the youth towards compliance with certain lexical norms. We have stated that the participants of the survey deem necessary to behave responsibly while choosing a lexical unit during formal communication (see Fig. 8).

For instance, 62.8% of the surveyed never admit of lexical repetitions, though in internet-communication this index is much lower (43.2%) and is almost two times less

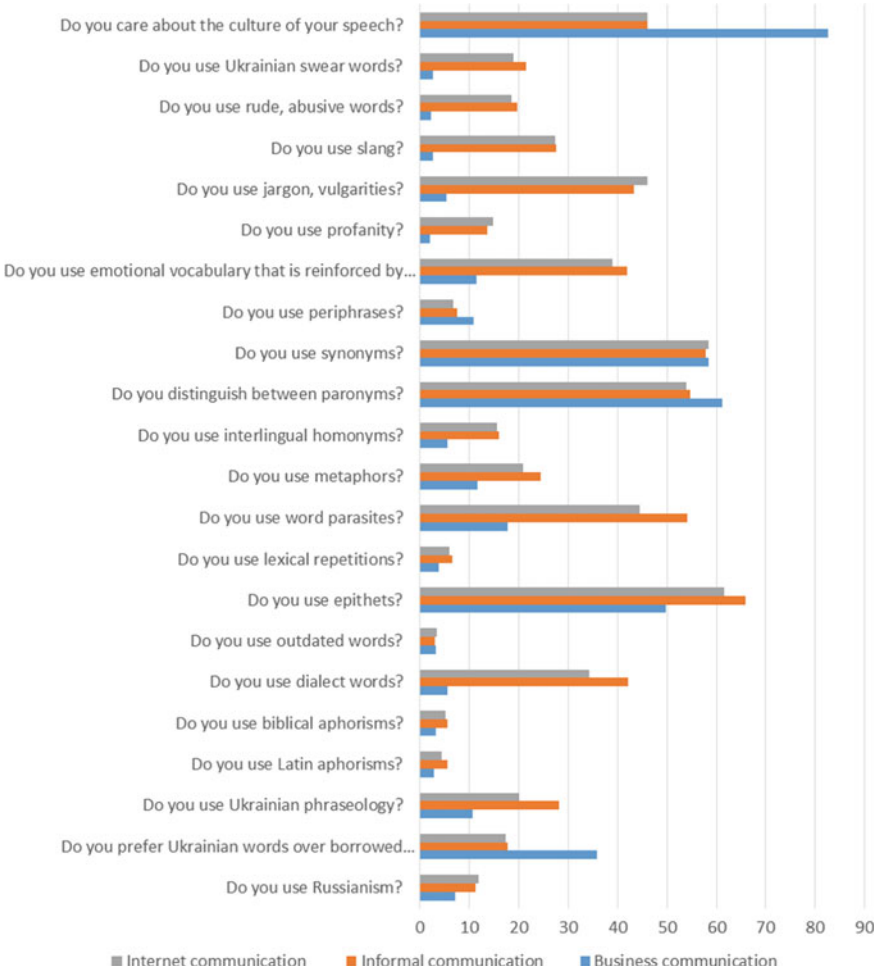

Fig. 8 Percentage of lexical rules compliance in different communication situations

in informal communication (36.7%). Another bright example refers to using word parasites. During business communication, 30.1% of respondents try to avoid them, but under informal conditions only 3.4%, during internet-communication—9.2% (see Fig. 9).

The difference in using interlingual homonyms is also significant: 55% of the surveyed never confuse them during official communication, 25.3%—during informal communication and 28.1%—during internet-communication (see Fig. 10).

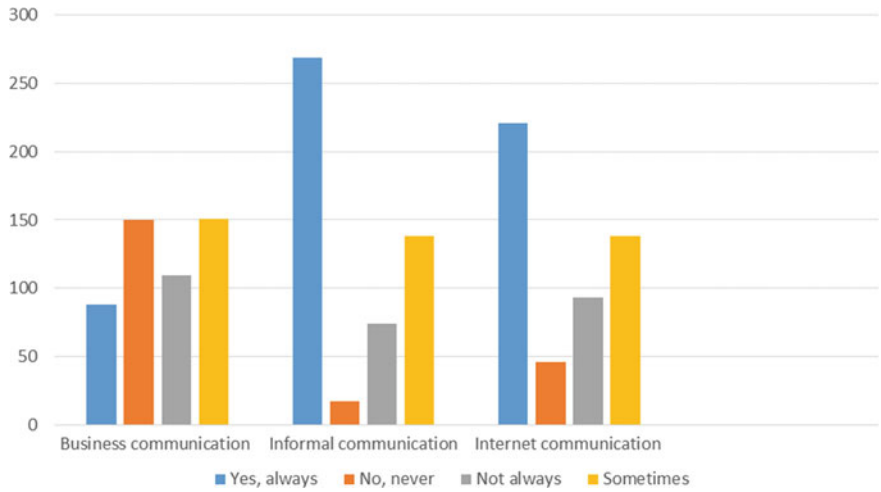

Fig. 9 Do you use word parasites?

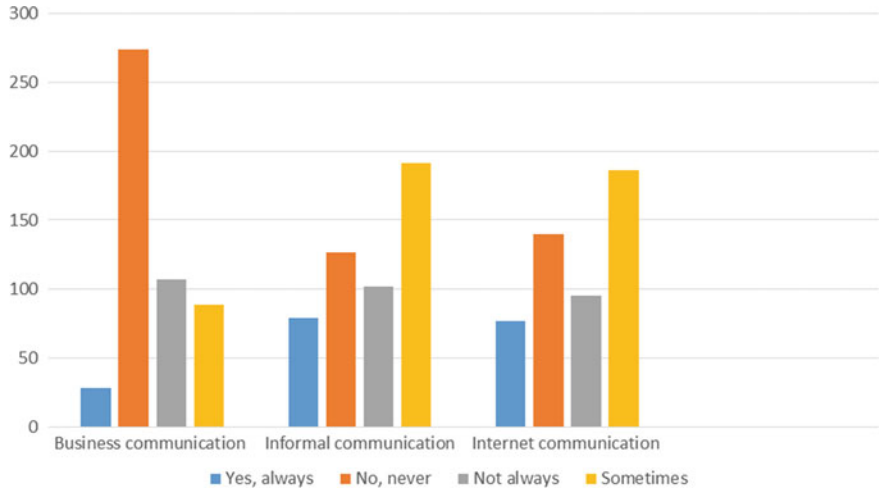

Fig. 10 Do you use interlingual homonyms?

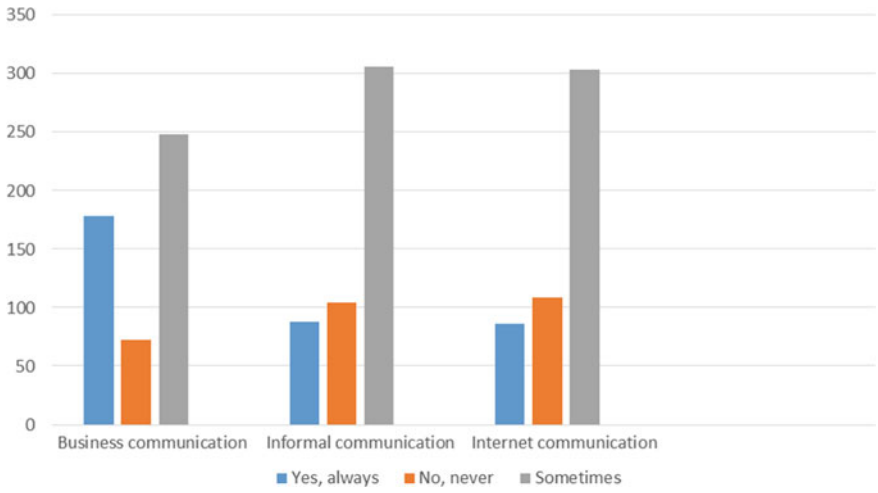

Fig. 11 Do you prefer Ukrainian words over borrowed equivalents?

In current conditions of globalisation, the problem of using borrowed vocabulary has become especially actual. Contemporary researches have stated the jeopardising influence of the new English borrowings on the lexical system of the Ukrainian language [41]. The materials of our research have proved the high level of indifference of the young generation of Ukrainians to the use of properly Ukrainian units of speech instead of English barbarisms which are becoming "fashionable" today. The highest frequency of using borrowed lexical units is observed during internet-communication: 21.9% never change a foreign word for its Ukrainian equivalent, 60.8% do it sometimes, and only 17.3% of the students have stated that they prefer native lexical units. As we can see on Fig. 11, these indexes, unfortunately, are very high as well during formal communication.

Very interesting results have been observed regarding distinguishing between meanings of paronyms. The answers of the survey participants to this question differ not too significantly in different communicative situations: in business-communication 61.1% of respondents answered "yes, always", in informal communication—54.6%, in internet-communication—53.8%. It indicates, in our view, that preciseness of an expression for the contemporary youth is an important aspect of communication. Unfortunately, however, only a little bit more than a half of the survey participants apply this lexical norm steadfastly. Thus software means, able to help with correct use of similarly sounding words, would become a convenient means to reach a high level of speech culture.

4 Conclusions and Practical Recommendations

The conducted research has indicated only 55.2% of the respondents to state that they constantly care about the culture of their speech, other more than 40% of surveyed to answer that they try, strive or aspire to follow lexical norms in different communicative situations. Thus, we can state disconsolate statistics, which affirm significant tendency for youth to violate lexical norms, particularly at the level of Internet-communication. However, the fact that only four respondents (0.8%) have stated that they never care about compliance with the norms of the Ukrainian literary language, but more than 99% of those having filled out the questionnaire are inclined to improving their speech competence, is a cause for optimism. Thus, we believe the task of creating software means to provide the opportunity of self-improvement for users, particularly at the lexical level, to be actual and prospective.

Learning the typical violations of the lexical speech norm in the student environment will allow to detect typical and not typical mistakes, thus further the creation of an automated system to react to the confusion of words, which have similar sound (paronyms), unmotivated use of words (medley, jargon, swear), irrelevant tautology, unnecessary loquacious, etc. On the grounds of concrete data provided in this research, we can separate out three main directions for improvement of the available software which examines compliance with the norms, or for designing new software products: (1) to correct lexical mistakes, (2) to check appropriate use of lexical units, (3) to suggest lexical units to improve a text.

References

1. Farion, I.: Language Norm: Destruction, Search, Restoration. Misto NV, Ivano-Frankivsk (2010)
2. Bralić, S.: Deviations from the language norm—the Italian language in the digital age. Folia Linguistica et Litteraria **7**(35), 235–257 (2021). https://doi.org/10.31902/FLL.35.2021.12
3. Yus, F.: An outline of some future research issues for Internet pragmatics. Internet Pragmat. **302**(1), 161–187 (2019). https://doi.org/10.1075/ip.00018.yus
4. Yus, F.A.: Cognitive pragmatics of the phatic Internet. In: Emotion in Discourse. Pragmatics & Beyond New Series, vol. 302, pp. 161–187 (2019). https://doi.org/10.1075/pbns.302.07yus
5. Tsoumou, J.M.: Analysing speech acts in politically related Facebook communication. J. Pragmat. **167**, 80–97 (2020). https://doi.org/10.1016/j.pragma.2020.06.004
6. Vazquez-Cano, E., Holgueras, G., Ana, I., Saez-Lopez, J.M.: An analysis of the orthographic errors found in university students' asynchronous digital writing. J. Comput. High. Educ. **31**(1), 1–20 (2019). https://doi.org/10.1007/s12528-018-9189-x
7. Makilahde, A., Leppanen, V., Itkonen, E.: Norms and normativity in language and linguistics basic concepts and contextualisation. In: Normativity in Language and Linguistics. Studies in Language Companion Series, vol. 209, pp. 1–28 (2019). https://doi.org/10.1075/slcs.209.01mak
8. Ashwini, K., Brundha, M.P., Preejitha, V.B.: A survey on increasing spelling errors due to increase use of digital technology among students. Biosci. Biotechnol. Res. Commun. **13**(7), 247–250 (2020). https://doi.org/10.21786/bbrc/13.7/41

9. Engblom, C., Andersson, K., Åkerlund, D.: Young students making textual changes during digital writing: types, causes and consequences for the texts. Nordic J. Digit. Lit. **15**(3), 190–201 (2020). https://doi.org/10.18261/issn.1891-943x-2020-03-05
10. Al-Ahdal, A.A.M.H., Algouzi, S.: Linguistic features of asynchronous academic netspeak of EFL learners: an analysis of online discourse. Asian ESP J. **17**(32), 9–24 (2021)
11. Hilte, L., Vandekerckhove, R., Daelemans, W.: Adolescents' perceptions of social media writing: has non-standard become the new standard? Eur. J. Appl. Linguist. **7**, 189–224 (2019). https://doi.org/10.1515/eujal-2019-0005
12. Akhmadgalieva, G.G., Sattarova, G.G.: Orthographic mistakes in the Internet and their influence on the literacy of Tatar students. Mod. J. Lang. Teach. Methods **7**(9), 580–586 (2017)
13. Fandrych, C., Wallner, F.: Functional and stylistic features of spoken advanced learner language: methodological and conceptual considerations based on GeWiss. Zeitschrift Fur Germanistische Linguistik **50**(1), 202–239 (2022). https://doi.org/10.1515/zgl-2022-2053
14. Khisamitdinova, F.G., Nuersyati, N., Denmukhametova, E.N., Fatkhullova, K.S.: Phraseological synonymy in the Tatar language. Int. J. Soc. Cult. Lang. **10**(1), 135–142 (2022). https://doi.org/10.22034/ijscl.2021.243622
15. Wan, I.-P., Allassonniere-Tang, M.: A corpus study of lexical speech errors in Mandarin. Taiwan J. Linguist. **19**(2), 85–118 (2021). https://doi.org/10.6519/TJL.202107_19(2).0003
16. Vergeiner, P.C., Buchner, E., Fuchs, E., Elspass, S.: Concepts of language norms in the realm of higher education in Austria. Zeitschrift fur Dialektologie und Linguistik **86**(3), 284–330 (2020). https://doi.org/10.25162/zdl-2019-0011
17. Uchihara, T., Eguchi, M., Clenton, J., Kyle, K., Saito, K.: To what extent is collocation knowledge associated with oral proficiency? A corpus-based approach to word association. Lang. Speech **65**(2), 311–336 (2022). https://doi.org/10.1177/00238309211013865
18. Kumar, A., Das, S.: Typology for linguistic pattern in English-Hindi journalistic text reuse. Int. J. Inf. Technol. Comput. Sci. (IJITCS) **8**(8), 75–86 (2016). https://doi.org/10.5815/ijitcs.2016.08.09
19. Mumtaz, D., Ahuja, B.: A lexical approach for opinion mining in Twitter. Int. J. Educ. Manag. Eng. (IJEME) **6**(4), 20–29 (2016). https://doi.org/10.5815/ijeme.2016.04.03
20. Doumi, N., Lehireche, A., Maurel, D., Abdelali, A.: A semi-automatic and low cost approach to build scalable lemma-based lexical resources for Arabic verbs. Int. J. Inf. Technol. Comput. Sci. (IJITCS) **8**(2), 1–13 (2016). https://doi.org/10.5815/ijitcs.2016.02.01
21. Arya, C., Dwivedi, S.: Keyphrase extraction of news web pages. Int. J. Educ. Manag. Eng. (IJEME) **8**(1), 48–58 (2018). https://doi.org/10.5815/ijeme.2018.01.06
22. Sarmah, J., Sarma, S.: Survey on word sense disambiguation: an initiative towards an Indo-Aryan language. Int. J. Eng. Manufact. (IJEM) **6**(3), 37–52 (2016). https://doi.org/10.5815/ijem.2016.03.04
23. Ološtiak, M., Rešovská, S.: A dictionary of Slovak neologisms (a project description). Int. J. Lexicogr. **34**(3), 302–314 (2021). https://doi.org/10.1093/ijl/ecaa029
24. Bozděchová, I., Klégr, A.: Pseudo-anglicisms: Czech neologisms based on English words. Slovo a Slovesnost **83**(1), 3–27 (2022)
25. Storjohann, P.: Paronymy and language change. Muttersprache **130**(2), 144–163 (2020)
26. Risberg, L., Langemets, M.: The problem of paronyms in Estonian. Keel Ja Kirjandus **64**(10), 903–926 (2021). https://doi.org/10.54013/kk766a4
27. Dawley, E.: Lexical cleansing: anglicisms and Francophone Québécois identity. Fr. Rev. **95**(3), 35–55 (2022). https://doi.org/10.1353/tfr.2022.0050
28. Durčević, J.: English in Montenegro: examining the perception of anglicisms and their equivalents in Montenegrin. Slavic East Eur. J. **65**(2), 369–383 (2021)
29. Bańko, M., Witalisz, A., Hansen, K.: Linguistic purism and loanword adaptation techniques: the case of polish. Lang. Aware. **31**(1), 95–116 (2022). https://doi.org/10.1080/09658416.2021.1990306
30. Niculescu-Gorpin, A.-G., Vasileanu, M.: Acceptability and diffusion of luxury Anglicisms in present-day Romanian. Pragmat. Cogn. **25**(1), 86–121 (2018). https://doi.org/10.1075/pc.18007.nic

31. Andruszkiewicz, M.: Linguistic norm in legal language and legislative language—the issue of codification. Int. J. Legal Discourse **5**(2), 269–283 (2020). https://doi.org/10.1515/ijld-2020-2036
32. San Martín, A.: Contextual constraints in terminological definitions. Front. Commun. **7**, art. no. 885283 (2022). https://doi.org/10.3389/fcomm.2022.885283
33. González-Oñate, C., Fanjul-Peyró, C., Salvador-Harsh, E.: Anglomania's influence on professional communication jargon in Spain. Historia y Comunicacion Social **26**(2), 603–616 (2021). https://doi.org/10.5209/hics.69204
34. Ramsey, R.E.: Individual differences in word senses. Cogn. Linguist. **33**(1), 65–93 (2022). https://doi.org/10.1515/cog-2021-0020
35. Madukwe, K.J., Gao, X.: The Thin Line Between Hate and Profanity. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), pp. 344–356 (2019). https://doi.org/10.1007/978-3-030-35288-2_28
36. Mashudi, R., Rahmat, H., Sanudin, S.R., Suliman, S., Musanif, A.M.: Rule of interaction in the press' communicative events interview. GEMA Online J. Lang. Stud. **17**(3), 70–85 (2017). https://doi.org/10.17576/gema-2017-1703-05
37. Fatchul, M., Rusma, N., Eka, P.E.: Rethinking arbitrariness of language and its implication in language use. Cogent. Arts Humanit. **8**, 1 (2021). https://doi.org/10.1080/23311983.2020.1868687
38. Kunch, Z.: Ancient idiomatic phrases as socio-psycholinguistic indicators in diplomat's speech. Current issues of the humanities: interuniversity collection of scientific works of young scientists of Drohobych State Pedagogical University named after Ivan Franko. **28**(1), 54–59 (2020). https://doi.org/10.24919/2308-4863.2/28.208632
39. Kunch, Z.: Imagery of speech as a sign of language culture (on the example of metaphor). Ukrainian meaning: scientific collection. 14–22 (2018)
40. Mykytyuk, O.: Culture of Speech: Features, Tasks, Interests. Lviv (2014)
41. Farion, I., Kunch, Z., Vasylyshyn, I., Mykytyuk, O., Mentynska, I.: Terminological Actualization of Ukrainian Linguistic Reality: Monograph, 232 pp. Lviv (2020)

Linguistic Images of Man and Woman in the Story of Ivan Franko "Cross-Paths": Attributive Compatibility

Sofiia Bulyk-Verkhola, Myroslava Hnatyuk, Iryna Shmilyk, Yuliya Tehlivets, and Liliia Kharchuk

Abstract The study, based on the online concordance of Ivan Franko's story "Cross-Paths", collected a lexeme inventory to denote the linguistic image of a man (13 units) and a woman (7 units). Attributive models are revealed. In the most frequent models of substantive man/woman + single adjective groups are distinguished (by internal properties (positive, negative, neutral); by external features (positive, negative, neutral); by age (neutral)) and their percentage frequency is clarified using. The model of substantive mister/пан + apposition is classified into three types and their frequency of combination is represented. A comparative analysis of attributive pronoun models to denote linguistic images of man and woman is demonstrated.

Keywords Statistical research language image of man and woman · Attributive compatibility · Corpus-based analysis · Computer lexicography · Collocation identification and extraction · Concordance · Idiolect speech of Ivan Franko

1 Introduction

Franco-scientific research has always been and continues to be in the focus of attention not only of literary critics, but also of linguists, who reveal the diversity of creative and scientific figures of Kameniar.

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Modern Frankian linguistic covers vocabulary, textology and lexicography, linguistic stylistics, onomastics, syntax, terminology, linguistic and orthographic editing of literary and scientific heritage, folklore and dialect speech, formation of the Ukrainian literary language, linguo-communicative, cognitive and linguistic-statistical dimensions of I. Franko's prose, theory of linguo-personology etc. [1–3].

Despite the large number of works in the internet linguistics work [4–7], there are still a number of linguistic issues in related to Kameniar's work that have not yet been studied. Among them there is the linguistic image of man and woman in the prose of Ivan Franko, in particular in the novel "Cross-Paths", in the light of the latest methods—the calculation of analyzed lexeme and identifying attributive compatibility based on electronic text. This linguistic and statistical analysis of gender was performed for the first time in this article, which indicates the relevance of the topic. At the present stage linguistics shows an increased interest in studying the relationship between the world, man (people) and language, which determines the relevant aspect of the analysis of artistic speech. Accordingly, it is now extremely important to study the works of Ivan Franko, taking into account the peculiarities of national and individual-authorial paintings of the world, representing the category of linguistic image.

The purpose of the article is to perform a linguistic and statistical analysis of the linguistic image of men and women and to investigate the attributive characteristics of gender stereotypes on the material of Ivan Franko's novel "Cross-Paths".

Achieving this goal involves the following tasks:

1. To reveal the interpretation of the concept of "language image" in linguistics.
2. Identify the gender specificity of the writer's artistic idiosyncrasy.
3. Separate lexeme inventory to denote the linguistic images of men and women.
4. Model the adjectival compatibility of masculine and feminine lexemes.
5. Analyze the attributive characteristics of linguistic images of men and women in the individual author's picture of the world.

The object of research is the category of linguistic images of men and women in the story "Cross-Paths" by Ivan Franko.

The subject of research is attributive characteristics of lexical inventory to denote the linguistic images of men and women.

The source base of the research was a card index created on the basis of a continuous sample of Ivan Franko's online concordance "Cross-Paths". A total of 1180 fixations were analyzed.

2 Research Methods

Scientific research has led to the choice of the following general scientific and linguistic methods:

Thanks to the deductive approach, the linguistic image of a man and a woman in an artistic text is described and the following lexical inventory is singled out: man, lad, husband, youth, junior, teenager, youngster, young man, gentleman, woman, young lady, wife, girl, miss, lady, lass.

The inductive method made it possible to summarize the results of specific observations and show a general picture of linguistic images of gender stereotypes in the novel "Cross-Paths".

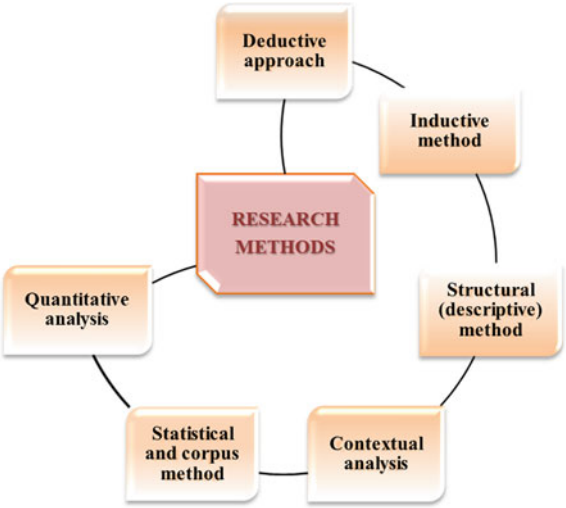
The collected material is classified and described using a structural (descriptive) method, taking into account the following successive stages: inventory—selection of language units of men and women; segmentation—the division of the selected units of men and women into smaller constituent units (lexical inventory)—masculine (13 units), feminine (7 units); taxonomy—classification of lexical units by attributive compatibility and part-of-speech affiliation, interpretation—identification of features of taxonomy groups.

The main analysis of the implementation of the language image of gender stereotypes on the material of artistic speech is contextual analysis, the use of which helped to identify the meaning of lexemes, to determine their compatibility in microcontexts, to identify emotional connotations. It is appropriate to combine in this research a distributive analysis of language phenomena, according to which the division of language units and understanding of their properties are considered on the basis of their isolation in the speech flow, i.e. take into account the context. Distributive modeling in lexicography makes it possible to shed light on the functioning of a word and its compatibility. This aspect of the study is found in experts in applied linguistics [8–10].

With the development of computer technology, new methods of text research have emerged, including writers' languages, including statistical and corpus, which attract the special attention of linguists [11–21]. Summary information on the statistical approach in the analysis of gender-labeled units is taken from the publication of Gadzalo [22], who emphasizes that "Statistical methods, as specifically targeted, are considered as one of the most effective and valid methods of researching gender-marked units in applied linguistics. Statistical methods are a set of techniques and principles according to which the collection, systematization, processing and interpretation of statistical data is carried out in order to obtain scientific and practical conclusions. Statistical methods are widely used in modern linguistics. Among Ukrainian researchers, these methods are also popular. It is worth mentioning here that Matthew Newman [23] worked on improving James Pennebaker's LIWC (Linguistic inquiry and word count) program (2001). He created a large body of texts (more than 500,000 text files of various industries and styles). Gadzalo [22] also emphasizes that "The usage of these methods is relevant today due to the rapid development of information technology and the increasing computerization of society" and summarizes: "the statistical approach is still poorly used by linguists in gender studies".

Elements of quantitative analysis allowed us to determine the most frequent attributive characteristics of "muscular" and "feminine" in Ivan Franko's novel "Cross-Paths". And the collection of material was realized with the help of the body

Fig. 1 Research methods



of the text—I. Franko's online concordance "Cross-Paths" [24]. This is one of the effective tools for studying the literary text of Kameniar, thanks to which we were able to apply the method of continuous sampling of words to denote male and female articles. This indicates that such a modern lexicographic method of text processing has many advantages in linguistics, as it gives a complete index of words in the immediate and extended contexts and the ability to describe and accurate statistics of the studied material. This integrated application of two modern methods makes research promising and interesting.

Kulchytskyy [19] rightly remarked: nowadays there are many approaches and methods in the field of modern linguistics, although there has been an increasing tendency towards using quantitative methods for research. It is believed that on the verge of the two branches, namely linguistics and statistics, the modern scholars can obtain the most accurate and up to date results. This paper deals with the statistical analysis of the novellas written by the renowned Ukrainian writer Roman Ivanychuk. The analysis of the linguistic text by the means of statistics provide an in-depth perspective on the specific style of writing of the author (Fig. 1).

3 Analysis in the Linguistic Research

Linguistic images of man in Ukrainian studies have been studied by many linguists, in particular linguistic image of a young man in folklore and ethnographic texts, linguistic image of a girl in folk songs, creating the image of a woman, a man, linguistic images of family members (father, mother, parents), images of the Mother of God and the priest etc.

Linguists interpret the concept of linguistic image differently. We agree with the modern interpretation of the concept of "language image" Brickner [3], who on a large theoretical basis formulated his own understanding of the term—a fragment of the linguistic picture of the world, which is a verbalized set of ideas, knowledge, experience of specific objects and individual interpretation of the worldview. Barabash-Revak [25], studying the linguistic image of a young man, understands this concept as a "mental object", enshrined in language and culture between the objective world and the man-researcher of this reality".

Thus, the linguistic image is a complex reflection of the element of reality by means of language and is an abstract concept that is embodied in language and speech. The material basis of the linguistic image is formed by language units of different levels. The word is traditionally considered to be the minimum unit of language capable of conveying an image. Linguistic images arise at the junction of two systems: the system of artistic art vision in general and the language system in particular.

For example, Levchenko [26] modeled the statistical profiles of Ukrainian prose 1980–1999 and 2000–2020 by writers and men and emphasized the analysis of the statistical importance of indicators that could function as gender markers.

4 Gender in Linguistics and in the Work of Ivan Franko

How language represents men and women is important because it influences society's attitudes toward both sexes and perpetuates stereotypes. Today, there is even a special sociolinguistic discipline—gender linguistics, which studies language and linguistic behavior, taking into account the social gender specifics. Gender features of the linguistic picture of the world are essential manifestations of cognition of the world through the prism of male and female vision, integrating universal and nationally specific features, expressing features of nominative and communicative activities of men and women, and the impact of gender on language practice and language behavior. That is why the issue of gender conceptosphere today is one of the promising vectors of linguistic discourse.

It is worth mentioning that the term "gender" (English "gender") to denote the socio-cultural characteristics of gender in the scientific community began to be used in the late 60s of the twentieth century. American psychoanalyst Robert Stoller [27] is also the author of the concepts of "masculine" (male) and "feminine" (female), which have lost the function of determining grammatical gender (biological understanding), and provided the opportunity to understand and perceive gender as a social unit that performs certain social role and which is influenced by various factors, including education, upbringing, cultural traditions, etc.

The problem of gender research has aroused interest among many linguists [23, 27–29]. For example, Humeniuk [30] rightly determined gender as an ideological frame that assembles the idea of what it means to be a man or a woman in a certain culture, anon-linguistic category with linguistic ways of actualization. The researcher substantiated the key theoretical problems concerning gender-marking based on

English phraseology and their influence on the formation of the gender picture of the world. Humeniuk concluded that the semantic basis of gender markers on the material of English phraseological units predominantly consists of stereotypical-associative units, which are perceived as social activity and characteristics of the images of both sexes with certain asymmetry for male denotata. The connotations of words can illustrate this inequality and the double standards between men and women.

Ivan Franko was one of the first in Ukrainian history to raise the issue of creating equal and partnership relations between men and women. I. Franko developed the theoretical foundations of feminism in a number of literary articles, as well as engaged in the practical implementation of feminist ideas. The writer operated with such scientific concepts as "women's issues", "women's and men's periods in literature", "women's writing", "women's reading", "emancipation" and others.

5 Data Collection and Analysis

The interpretation of the compatibility of lexemes is today called one of the most important components for linguistic research, because it serves, firstly: syntagmatic potential of language as a system that directly goes into the syntagmatics of speech; secondly, the study of types of connectivity is necessary for the analysis of the connections of lexical units of the word, i.e. for semasiology; thirdly: each type of compatibility has its own sphere of use, and their comprehensive study contributes to the best possible expression of the characteristics and properties of different lexical units and their functioning in speech; fourthly: different types of compatibility (syntactic, lexical-semantic and stylistic) serve as fundamentally important and necessary criteria for creating discursive texts, as well as to describe the compatibility of words in dictionaries [31]. Connoisseur of combinatorial linguistics Dydyk-Meush [31], having demonstrated the linguocognitive description of lexical compatibility on the example of adjectival-substantive phrases of the Ukrainian language of the XVI–XVIII centuries, is convinced that to establish the semantic structure of any word—both fixed and not fixed in dictionaries, and the context is a priority and main condition for research".

Due to the defining component—context—we have chosen as a source the online concordance of the story "Cross-Paths" by Ivan Franko [24], which is a special type of dictionary that contains register words (word forms) all contexts or a selection of their use; is a "convenient tool for identifying fragments of the conceptual picture of the author's world", identifying the author's idiosyncrasy, verbalization of linguistic images of men and women in the literary text.

Collected lexeme inventory to denote the linguistic image of a man covers 13 units: ***чоловік*** (126 fixations—13.55%), ***чоловічок*** (2—0.21%), ***муж*** (20—2.15%), ***мужчина*** (8—0.1%), ***мужик*** (3—0.32%), ***хлоп*** (65—6.98%), ***хлопець*** (2—0.21%), ***хлопчина*** (2—0.21%), ***хлописько*** (4—0.43%), ***хлопчик*** (4—0.43%),

Table 1 Frequency of use of lexeme inventory to denote the linguistic image of a **man**

Lexeme	Fixations	Per cent (%)
чоловік	126	13.55
чоловічок	2	0.21
муж	20	2.15
мужчина	8	0.1
мужик	3	0.32
хлоп	65	6.98
хлопець	2	0.21
хлопчина	2	0.21
хлописько	4	0.43
хлопчик	4	0.43
парубок	11	1.18
пан	670	72.04
панич	13	1.39

парубок (11—1.18%), **пан** (670—72.04%), **панич** (13—1.39%) (see Table 1; Fig. 2).

Instead, the lexeme inventory to denote the linguistic image of a woman has 7 units, the frequency of use of which compared to masculine names is lower: ***жінка*** (92—36.5%), ***жіночка*** (3—1.19%), ***жонца*** (1—0.39%), ***дівчина*** (6—2.38%), ***дівчинка*** (2—0.79%), ***пані*** (108—42.85%), ***паннночка*** (40—15.87%) (see Table 2; Fig. 3).

In the proposed research, the numerical corpus is created by adjectival-noun phrases, which according to the terminological classification of Dydyk-Meush [31] are perceived as simple two-component compounds with the main component-noun

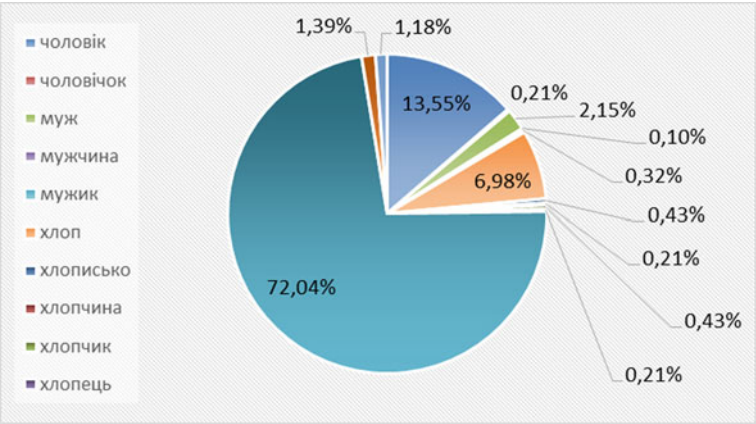


Fig. 2 Frequency of use of lexeme inventory to denote the linguistic image of a **man**

Table 2 Frequency of use of lexeme inventory to denote the linguistic image of a **woman**

Lexeme	Fixations	Per cent (%)
жінка	92	36.5
жіночка	3	1.19
жонца	1	0.39
дівчина	6	2.38
дівчинка	2	0.79
пані	108	42.85
панночка	40	15.87

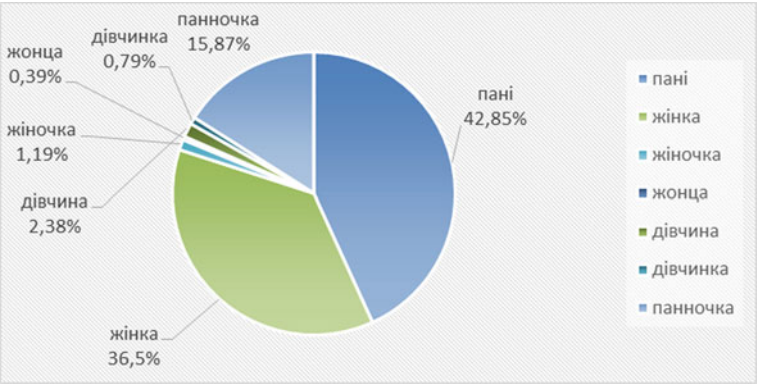


Fig. 3 Frequency of use of lexeme inventory to denote the linguistic image of a **woman**

and contact/remotely located dependent component-adjective, which are related among themselves mostly due to coordination. According to the materials of the concordance, the object of analysis was those adjective-noun phrases in which the forms of different parts of speech (noun, pronoun and numerator) or phrases, phraseologies and metaphorical expressions perform an adjectival function.

The lexeme man is understood as: 1. A male person; opposite woman. 2. A married person in relation to his wife. 3. The same as man. 4. The peasant [32].

I. Franko uses the nomination man mostly in the first sense, to which the following attributive models are found:

- ***substantive man + single adjective***: *stupid* man, *bile* m., *old* man, *interesting* m., *dangerous* m., *honest* m., *clever* m. (3); *young* m., *half-drunk* m., *high* m., *gloomy* m., *silent* m., *sinful* m., *senior* m., *shameless* m., *cruel* m., *having* m., *selfish* m., *calm* m., *educated* m., *choir* m. (2), *poor* m., *alien* m. (4: with *another* man, *in front of another* man, *not another* man), *outsider* m., m. *liberal*, m. *hardened*, *baptized* m., *insane* m., *simple* m., *poor* [meaning—*poor*] m. *almost cried*; (3), *small* m., *thin* m., *the most capable* m., *the most honest* m., *semi-conscious* m., *foolish* m., *free* m., m. *light*, m. *scientist*, *good* m. (3), *decent* m. (2), *disgusting* m., *bad part of* m., *evil* m.

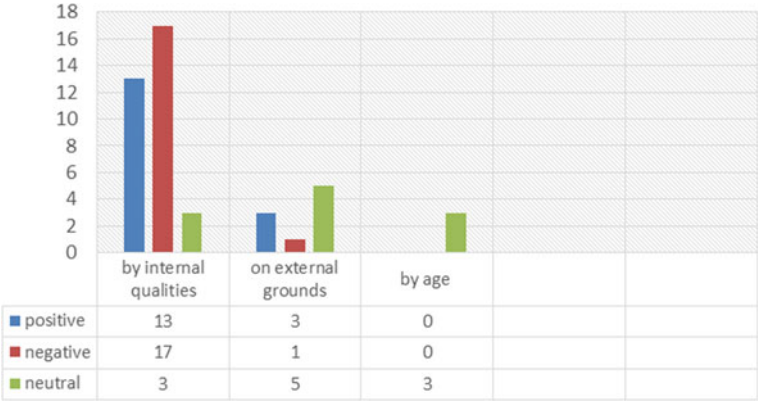


Fig. 4 Frequency of use of the attributive component of the lexeme **man**

Within the "substantive man + single adjective" model, attributes can be grouped into the following groups (see Fig. 4):

(a) by internal qualities: **positive** (*interesting*, *honest*, *smart*, *decent*, *calm*, *educated*, *hardened*, *most capable*, *most honest*, *bright*, *learned*, *kind*, *decent*), **negative** (*stupid*, *bilious*, *dangerous*, *half-drunk*, *gloomy*, *sinful*, *shameless*, *cruel*, *selfish*, *chorus*, *insane*, *poor* [meaning—*poor*], *semi-conscious*, *foolish*, *disgusting*, *unkind*, *evil*), **neutral** (*silent*, *simple*, *liberal*);
(b) on external grounds: **positive** (*having*, *baptized*, *free*), **negative** (*poor*), **neutral** (*tall*, *alien*, *outsider*, *small*, *thin*);
(c) by age (*young*, *old*, *senior*).

Franko uses the lexeme **man** mostly in the meaning of "male person". The most frequent model was ***the substantive man + single adjective***, within which the attributes can be combined into the following groups: internal properties: positive (*honest*)—28.89%, negative (*cruel*)—37.78%, neutral (*silent*)—6.67%; by external signs: positive (*free*)—6.67%, negative (*poor*)—2.22%, neutral (*high*)—11.1%; by age: neutral (*young, old, senior*)—6.67% (see Table 3).

- ***substantive man + adjective phrase***: *deeply immoral* man, *unusually intelligent* men, *rudely experienced* man, a man *with very rough nerves or deaf*; *not such an evil* man; a man *with a sense*, then—*an idealist*; a man *burdened with family*; a man *in a short work suit*, a man *a little stooped*; a man *she knew*;
- ***substantive man + indicative pronoun***: fear of *this* man; similar to the feeling of *that* man [who returned home from the solitude of the forest to the bosom of a large and eloquent family]; beware of *that* man; this man's *his* own cruelty; *that* shameless and cruel man; *that* man [carries in his chest a deep, barely healed love wound]; antipathy to *this* man; I am *such* a man: either a gentleman or a missing person; with *such* a man; *this* man is the cause of my unhappiness; *this* disgusting man;

Table 3 The percentage of use of the attributive component of the lexeme **man**

Group	Fixations	Per cent (%)
By internal qualities	Positive (*honest*)	28.89
	Negative (*cruel*)	37.78
	Neutral (*silent*)	6.67
On external grounds	Positive (*free*)	6.67
	Negative (*poor*)	2.22
	Neutral (*high*)	11.1
By age	Neutral (*young, old, senior*)	6.67

- ***substantive man + phraseology***: man *is bilious and angry at the tongue*; I am such a man: *either a gentleman or a missing person*; look for a man to be a *sincere boy's soul*, *a boy's bone*; *strange creation of* man; the call of a good, foolish man, *but with the finger of a child*;
- ***substantive man + metaphorization***: a man's *stupid heart*; a man *of body and bones*;
- ***substantive man + subordinate definite component***: similar to the feeling of a man *who returned home from the solitude of the forest to the bosom of a large and eloquent family*; a man who *does not shy away from the dirtiest agreements*; a man *who has suicidal thoughts*; to give oneself the appearance of a man *who walks freely and quite unexpectedly meets an acquaintance*; like a man *peering into the abyss*; a man *who in everything and everywhere has a different opinion from the whole community*; like a man *who bumps into a wall in the dark and doesn't know where or how to climb or go around it*.

I. Franko uses the lexeme *small man/cholovichok* in the third sense (man) in the model of the ***substantive man + adjective decent***: although a Jew, but decent m.

The lexeme man is understood as: 1. Reduced-affectionate to men; // The same as a child. 2. Size. The same as the pupilla [32]. In the analyzed concordance, this word was recorded in the first meaning 6 times and the following models were identified:

- ***substantive small man/cholovichok + single adjective***: *little* small man, *short* small man, *thin* small man;
- ***substantive small man/cholovichok + adjective form or phrase***: a small man *from the crowd*, a small man i*n his forties*;
- ***substantive small man/cholovichok + subordinate definite component***: a small man *surrounded by a bunch of peasants.*

The lexeme **husband/man/muzh** is understood as follows: 1. book. State, scientific, public, etc. leader. 2. solemnly Man (in 2 meanings) [32].

In the analyzed concordance 20 times we fix this lexeme in the second value and we single out the following models:

- ***substantive husband/man/muzh + single adjective***: *future* husband;

- ***substantive husband/man/muzh + possessive pronoun***: *your* husband, *my* husband, *her* husband, *own* husband.

The **man/muzhchyna** interprets the lexeme dictionary as: "size, rarely. The same as man 1 [32].

In the analyzed concordance we fix 8 times in the following models:

- ***substantive man/muzhchyna + single adjective***: black mustached man;
- ***substantive man/muzhchyna + pronoun***: *which* man, did not have romances with *which* men.

The lexeme **man/muzhyk** in the dictionary is explained as follows: 1. conversational Peasant. 2. portable, contemptuous, abusive. About an uneducated, rude person; redneck. 3. conversational Man (in 1 sign.), Man. 4. dialect Husband (in 2 meanings), wife (in 2 meanings) [32].

During our analysis, the use of the lexeme *man/muzhyk* in the first sense in the adjectival model of the ***substantive man/muzhyk + pronoun***: *those* men, *this* man.

The lexeme ***man/khlop*** has the following meanings: 1. despised. Peasant, peasant in general or serf. 2. dial. Man, man, boy [32].

I. Franco uses this lexeme in the first sense 65 times in the following models:

- ***substantive man/khlop + single adjective***: *perfect* man, *Rus'kyi* man, *stupid* man;
- ***substantive man/khlop + pronoun***: *that* man, some man, *those* men, with *his* man, about *your* man, *our* men, with *those* men, *those* stupid men;
- ***substantive man/khlop + adjective part of the compound predicate***: man *is sacred*.

The lexeme **guy** interprets dictionary as follows: 1. A child or adolescent male; // Same as son; // Young man, young man, young man. 2. trans. many Used as the name of men (mostly when addressing). 3. Adolescent Servant [32].

In the analyzed concordance we fix twice in the first value. One of the uses is the model ***substantive guy + single adjective***: *capable* guy.

The lexeme **boy/khlopchyna** has the following meaning: size. The same as the guy [32].

In the analyzed concordance we fix 2 times and find in the model the ***substantive boy/khlopchyna + single adjective***: *weak* boy.

The lexeme **boy/khopchysko** in "Cross-Paths" is used three times without adjectival characteristics. Unfortunately, dictionaries do not provide an interpretation of this word. In our opinion, the lemma khopchysko acquires a pejorative meaning from the token khlop.

The token **boy/khlopchyk** has the following meaning: Male child [32].

In the analyzed concordance we fix 1 time in the model of ***the substantive boy/khlopchyk + indicative pronoun***: this boy.

The dictionary interprets the lexeme of **young man/parubok** as follows: 1. A young man; youth. 2. Unmarried man [32]. In the analyzed concordance we fix 11 times in the following models:

- ***substantive young man/parubok + single adjective***: *young* guy, *drunk* young man;
- ***substantive young man/parubok + adjectival form***: a young man *under a mustache*, a very *adult* young man, the young man *was very healthy.*

The dictionary explains the lexeme **mister/pan** as follows: 1. Landlord in old Poland, Lithuania, Ukraine and Belarus; 2. He who held a privileged position in society, belonged to the affluent sections of the urban population, the intelligentsia; // One who has power over others; ruler, master. 3. In old Poland, Lithuania, Ukraine and Belarus—a polite form of address or name in relation to males; // In modern reality—a polite form of remembrance or address, usually to an official representative or citizen of another state; // Of course with the word-adjective—a respectful form of addressing a man in oral vernacular. Mr. Brother, Deputy—formula for addressing a man, used in the vernacular [32].

The analyzed concordance gives grounds to distinguish the lexeme **mister/pan** in the second and third meanings in the following models:

- ***substantive mister/pan + single adjective***: *good* mister/pan, *big* mister/pan, *young* mister/pan, other mister/pan, *local* mister/pan, *unknown* mister/pan, *county* mister/pan, *present* mister/pan;
- ***substantive mister/pan + adjective form***: *elongated* mister/pan, handfuls of mister/pan *in furs*;
- ***substantive mister/pan + pronoun***: *our* mister/pan, *this* mister/pan, *that* mister/pan, *no* mister/pan, the mister/pan *himself*; *that* mister/pan, *your* mister/pan, *some* mister/pan, *some* unknown mister/pan, *all* misters/pans;
- ***substantive mister/pan + numerator***: all *three* misters/pans, *several* more misters/pans;
- ***substantive mister/pan + phraseology or metaphorization***: mister/pan *is neither my brother nor my fiancé*; mister/pan *of his will*.

Compounds with appendage deserve special attention (see Fig. 5):

- ***substantive mister/pan + appendix—name of profession, type of activity, social status***: Mr. *Marshal* (134), Mr. *Adjunct*, Mr. *Educator* (8), Mr. *Lawyer*, Mr. *Patron* (71), Mr. *Trainee*, Mr. *Mayor* (12), Mr. *Didic* (2), Mr. *President* (29), Mr. *Secretary*, Mr. *Starosta* (116), Mr. *Councilor* (2), Mr. *Counselor* (9), Mr. *Presus* (3), Mr. *Inspector*, Mr. *Procurator* (6), Mr. *Count* (7), Mr. *Commissioner* (10), Mr. *Doctor*, Mr. *Builder* (3), Mr. *City Builder*; Mr. *Director*, Mr. *Official* (3), Mr. *Judge* (3), Mr. *Defender*, Mr. *Physicist* (4), Mr. *Emancipator*, Mr. *Lord* (2);
- ***substantive mister/pan + adjective—proper name (names, surnames)***: Mr. *Stalsky* (5), Mr. *Brykalsky* (6), Mr. *Eugene Brykalsky*, Mr. *Eugene* (4), Mr. *Schwartz* (8), Mr. *Wagman*, Mr. *Rafalovich* (3), Mr. *Schnadelsky* (14), Mr. *Leiba* (3), Mr. *Big*, Mr. *Schwartz* and Mr. *Schnadelsky*, Mr. *Resselberg*, Mr. *Przepyurski;*
- ***substantive mister/pan + appendix—name of profession, type of activity, social status + proper name***: Mr. *Judge Strahotsky* (2), Mr. *Educator Rafalovich*, Mr. *Marshal Brykalsky*, Mr. *Count Kshivotulsky*, Mr. *Patron Rafalovich* (2). It is worth

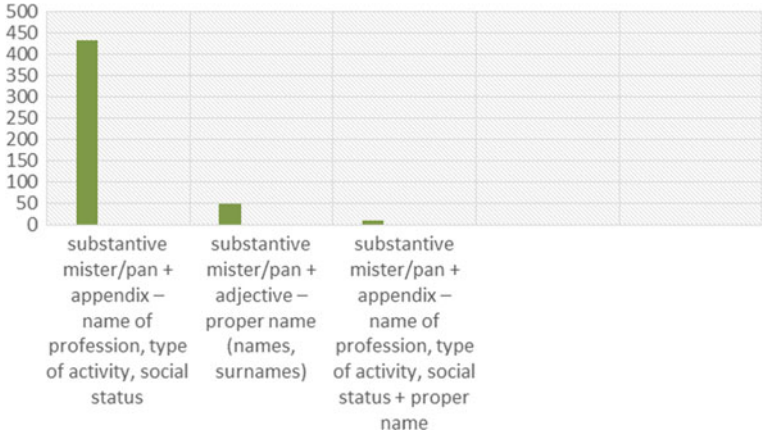


Fig. 5 Frequency of application of the attachments to the substantive **mister/pan**

noting that in this model the combination of the lexeme *mister/pan* with profession and surname predominates, while the addition of a name in such compounds is single (Mr. *Dr. Eugene Rafalovich*).

The frequency of use of the compound of the lexeme *mister/pan* with the adverb: substantive *mister/pan* + adjective—name of profession, type of activity, social status: (Mr. *Marshal*)—88.39%; substantive *mister/pan* + appendix—proper name (names, surnames): (Mr. *Stalsky*)—9.98%; substantive *mister/pan* + appendix—name of profession, type of activity, social status + proper name (Mr. *Judge Strahotsky*)—1.63% (see Table 4).

The lexeme *young mister/panych* is interpreted as follows: 1. The young unmarried son of the master, the lady (in 1 sign.); // figurative, ironic, contemptuous. A young man who stands out for his depraved behavior, unworked habits, overly refined manners, and so on. 2. An unmarried young man who belonged to the privileged sections of the population; // Lowered, spoiled young man; white pen [32].

In the analyzed concordance we fix 13 times in the following models:

- ***substantive young mister/panych + single adjective***: *good* young mister/panych, *hopeful* young mister/panych, *young* young mister/panych;

Table 4 The percentage of use of the compound of the lexeme ***mister/pan*** with the adverb

Compound *mister/pan* +	Fixations	Per cent (%)
Adjective—name of profession, type of activity, social status	Mr. *Marshal*	88.39
Appendix—proper name (names, surnames)	Mr. *Stalsky*	9.98
Appendix—name of profession, type of activity, social status + proper name	Mr. *Judge Strahotsky*	1.63

- ***substantive young mister/panych + indicative pronoun***: *those* young misters/panych, *that* young mister/panych, *this* young mister/panych.

The token **woman** is interpreted as follows: 1. A female person; opposite man. 2. An adult, unlike a little girl. 3. A married person in relation to her husband. // Generally a married woman [32].

I. Franko uses the nomination *woman* 92 times. The following attribute models have been identified:

- ***substantive woman + single adjective***: *rich* woman, *future* woman, *influential* woman, *beautiful* woman, *suffocated* woman, *envious* woman, *married* woman, *ideal* woman, *human* woman, *young* woman, *unmarried* woman w., *unhappy* (2) w., *pious* w., *oppressed* w., *smart* w., *beloved* w., *civilized* w., *honest* w., *married* (2) w.

Within the "substantive woman + single adjective" model, attributes can be grouped into the following groups (see Fig. 6):

(a) by internal qualities: positive (*influential, human, pious, intelligent, beloved, honest*), negative (*envious, unhappy, unhappy, oppressed*);
(b) on external grounds: positive (*rich, beautiful, ideal*), negative (*suffocated*), neutral (*future*);
(c) by social status: neutral (*married, unmarried, civilized*);
(d) by age: neutral (*young*).

Franko most often uses the lexeme **woman** in the meaning of "female person" in the attributive model of substantive *woman* + single adjective, where attributes can be combined into the following groups: internal properties: positive (*honest*)—30%, negative (*envious*))—20%; by external signs: positive (*good*)—15%, negative (*suffocated*)—5%, neutral (*future*)—5%; by social status: neutral (*married*)—20%; by age: neutral (*young*)—5% (see Table 5).

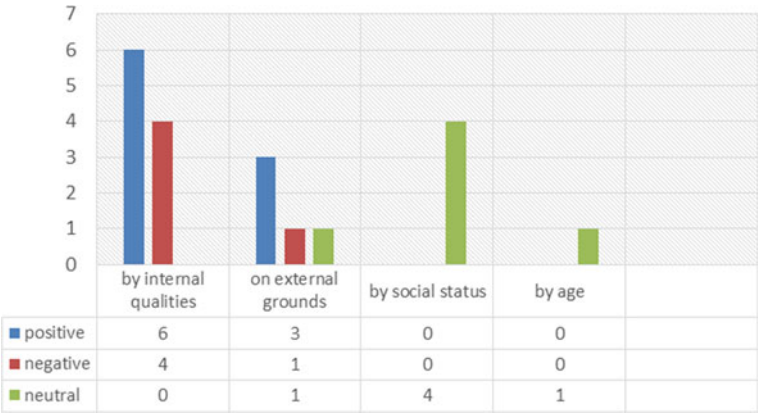


Fig. 6 Frequency of use of the attributive component of the lexeme **woman**

Table 5 The percentage of use of the attributive component of the lexeme **woman**

Group	Fixations	Per cent (%)
By internal qualities	Positive (*honest*)	30
	Negative (*envious*)	20
By external grounds	Positive (*good*)	15
	Negative (*suffocated*)	5
	Neutral (*future*)	5
By social status	Neutral (*married*)	20
By age	Neutral (*young*)	5

- ***substantive woman + possessive pronoun***: *my* woman (12), *your* woman (10), *your* woman (3), *his* woman;
- ***substantive woman + phraseology, metaphorization, comparison***: woman, *God forbid*; woman *devil's seed*; a woman *like a willow*; the woman, *where her positions are, will be accepted there*;
- ***substantive woman + application***: *blonde* woman, *comedian* woman.

The lexeme **woman/zhinochka** is a reduced-loving form to the token woman [32].

I. Franko uses the nomination woman only 3 times. The following attributive models are found here:

- ***substantive woman/zhinochka + single adjective***: *any* woman/zhinochka;
- ***substantive woman/zhinochka + possessive pronoun***: *my* woman/zhinochka;
- ***substantive woman/zhinochka + metaphorization, comparison***: woman/zhinochka *urban potion.*

The lexeme **wife/zhontsa** is not recorded in SUM. In his text, I. Franko used the following word form in the model ***substantive wife + adjective phrase*** (mister's "wife/zhontsa") in the following context: "*They are standing with their hats in their hands, apparently waiting for the 'wife', whether she will hire a milkman or a distiller tomorrow, at least fifteen cruisers a day*".

The lexeme **lady/pani** in the dictionary is recorded with the following meanings: 1. Married landowner in old Poland, Lithuania, Ukraine and Belarus // trans., Iron., Despised. A woman who stands out for her depraved behavior, non-work habits, overly refined manners, etc. 2. A female person who held a privileged position in society; // A person who has power over others; mistress, mistress // A woman who by appearance belongs to the privileged segments of the population. // Someone's wife. 3. In old Poland, Lithuania, Ukraine and Belarus—a polite form of addressing or naming privileged sections of society in relation to women // In modern reality—a polite form of addressing, mentioning, of course, an official or citizen of another state. // Respectful form of addressing women in the vernacular [32].

In I. Franko's "Cross-Paths" the second and third meanings in the following attributive models are realized:

- ***substantive lady/pani + single adjective***: *stone* lady, "*wealthy*" lady, *young* lady, *kind* lady;
- ***substantive lady/pani + adjective form***: lady *of home* (2);
- ***substantive lady/pani + pronoun***: *her* lady, *that* lady, *your* lady, lady *herself*;
- ***substantive lady/pani + adverb***: lady *Stalska* (5); lady *starostyna*, lady *Solenizantka*, lady *Stepmother of Miss*.

The **young lady/pannochka** is a reduced-loving form to the young **lady**: 1. A young unmarried landowner or daughter of a gentleman (in 1 sign.) In old Poland, Lithuania, Ukraine and Belarus. // figurative, iron., despised. A girl who stands out for corrupt behavior, unhealthy habits, overly refined manners, etc. // daughter of wealthy parents, owners. 2. Gentle, fragile or well-dressed girl. 3. Polite form of addressing or mentioning to young girls the privileged sections of the population of old Poland, Lithuania, Ukraine and Belarus [32].

In the analyzed concordance of the lexeme *young lady/pannochka* was recorded 40 times, mainly in the first value, which made it possible to distinguish the following models:

- ***substantive young lady/pannochka + single adjective***: *young* lady, *unfamiliar* young lady, *unknown* young lady, *passing* young lady;
- ***substantive young lady/pannochka + adjective form***: young lady *in mourning*;
- ***substantive young lady/pannochka + pronoun***: *my* young lady, *which one* of the young ladies;
- ***substantive young lady/pannochka + contracting defining component***: the same young lady *who made such a strong impression on him at the ball and on the street last year.*

The lexeme **girl** is usually interpreted as a young single woman; // Beloved, called [32]. Analysis of form **girl** showed that I. Franko used it in "Cross-Paths" 4 times in the following attributive models:

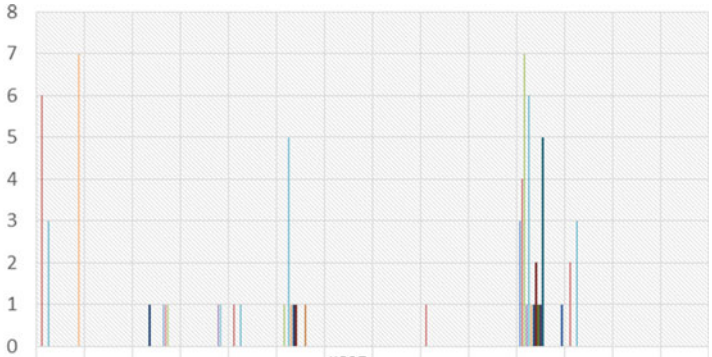
- ***substantive girl + single adjective***: *dear* girl, *calm* girl;
- ***substantive girl + adjective form***: *self-defined* girl;
- ***substantive girl + pronoun***: *this* girl.

The lexeme **girl/divchynka** as a female child [32] in the analyzed concordance is recorded twice in the model of ***substantive girl/divchynka + single adjective***: *little* girl.

The next step in our analysis was the comparison of attributive pronoun models to denote the linguistic images of man and woman. The frequency of combining a pronoun with lexemes to denote the linguistic image of a man (13 units) indicates the variety of categories of pronouns by meaning: **чоловік** (такий – 7, сей – 6, той – 3), **чоловічок** (0), **муж** (ваш – 1, твій – 1, мій – 1, її – 1), **мужчина** (котрий – 1, який – 1), **мужик** (сей – 1, той – 1), **хлоп** (той – 5, наш – 1, свій – 1, ваш – 1, якийсь – 1, його – 1), **хлопець** (0), **хлопчина** (0), **хлописько** (0), **хлопчик** (сей – 1), **парубок** (0), **пан** (наш – 7, той – 6, весь – 5, сей – 4, сам – 3,

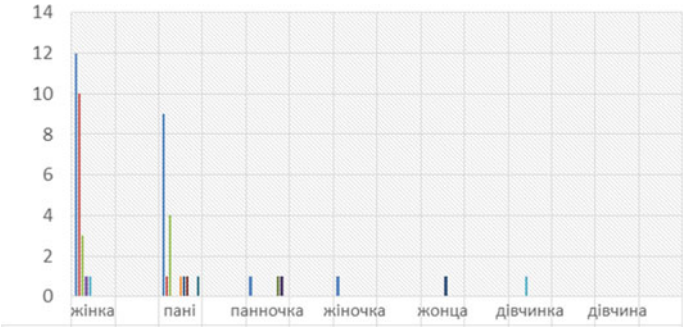
якийсь – 2, ніякий – 1, свій – 1, ваш – 1, тамтой – 1, отсей – 1, іньчий – 1), ***панич*** (той – 3, сей – 2) (see Fig. 7).

As you can see, in the combinations to denote the image of a man used 41 indicative pronouns, 17—possessive, 9—definite, 3—indefinite, 2—relative, 1—negative. Such a significant number of the use of indicative pronouns with lexemes to denote the linguistic image of a man indicates the importance and priority of his role in contemporary society. Instead, attributive models for the frequency of combination of pronouns with lexeme to denote the linguistic image of a woman (7 units) show the following indicators (see Fig. 8): ***жінка*** (моя – 12, твоя – 10, ваша – 3, твоя – 1,



	чоловік	чоловічок	муж	мужчина	мужик	хлоп	хлописьк о	хлопчина	хлопчик	хлопець	пан	панич	парубок
сам	0	0	0	0	0	0	0	0	0	0	3	0	0
сей	6	0	0	0	1	0	0	0	1	0	4	2	0
наш	0	0	0	0	0	1	0	0	0	0	7	0	0
ніякий	0	0	0	0	0	0	0	0	0	0	1	0	0
той	3	0	0	0	1	5	0	0	0	0	6	3	0
свій	0	0	0	0	0	1	0	0	0	0	1	0	0
ваш	0	0	1	0	0	1	0	0	0	0	1	0	0
якийсь	0	0	0	0	0	1	0	0	0	0	2	0	0
тамтой	0	0	0	0	0	0	0	0	0	0	1	0	0
отсей	0	0	0	0	0	0	0	0	0	0	1	0	0
весь	0	0	0	0	0	0	0	0	0	0	5	0	0
його	0	0	0	0	0	1	0	0	0	0	0	0	0
твій	0	0	1	0	0	0	0	0	0	0	0	0	0
мій	0	0	1	0	0	0	0	0	0	0	0	0	0
її	0	0	1	0	0	0	0	0	0	0	0	0	0
котрий	0	0	0	1	0	0	0	0	0	0	0	0	0
який	0	0	0	1	0	0	0	0	0	0	0	0	0
такий	7	0	0	0	0	0	0	0	0	0	0	0	0
іньчий	0	0	0	0	0	0	0	0	0	0	1	0	0

Fig. 7 Frequency of use of pronouns to the lexeme inventory to denote the linguistic image of a **man**



	жінка	пані	панночка	жіночка	жонца	дівчинка	дівчина
моя	12	9	1	1	0	0	0
своя	10	1	0	0	0	0	0
ваша	3	4	0	0	0	0	0
твоя	1	0	0	0	0	0	0
його	1	0	0	0	0	1	0
ся	0	1	0	0	0	0	0
її	0	1	0	0	1	0	0
та	0	1	0	0	0	0	0
уся	0	0	1	0	0	0	0
котра	0	0	1	0	0	0	0
сама	0	1	0	0	0	0	0

Fig. 8 Frequency of using pronouns of lexeme inventory to denote the linguistic image of a **woman**

його – 1), ***жіночка*** (моя – 1), ***жонца*** (її – 1), ***дівчина*** (його – 1), ***дівчинка*** (його – 1), ***пані*** (моя – 9, ваша – 4, твоя – 1, її – 1, та – 1, ся – 1, сама – 1), ***панночка*** (моя – 1, уся – 1, котра – 1). As evidenced by the concordance with lexemes to denote the image of a woman used 47 possessive pronouns, 2—indicative, 2—definite, 1—relative. Observations on the frequency of use of possessive pronouns for lexemes that create a linguistic image of a woman, we can conclude about her dependent role in society at that time, restrictions on rights, her belonging and subordination to man.

6 Conclusions

Thus, in modern linguistics there are different interpretations of the concept of language image. Having analyzed significant theoretical material, we use this term as a fragment of the linguistic picture of the world, which is a verbalized set of ideas, knowledge, and experience of specific objects, phenomena of reality, which preserves national and individual interpretation of worldview. Linguistic images arise on the border of two systems: the system of artistic vision in general and the language system in particular.

We consider the gender specificity of Ivan Franko's artistic idiosyncrasy through the prism of the attitude of both sexes in the society of that time and the writer's influence on the formation of stereotypes. I. Franko was one of the first in Ukraine to raise the issue of creating equal and partnership relations between man and woman. In a number of literary and journalistic articles, in private correspondence, he developed the theoretical foundations of feminism, considered the peculiarities of woman's status, family relations, characterized masculine virtues, identified gender features of Ukrainian national culture.

Franko uses the lexeme **man** mostly in the meaning of "male person". The most frequent model was ***the substantive man + single adjective***; also used the following adjectival models: ***substantive man + adjective phrase***: *deeply immoral* man; ***substantive man + indicative pronoun***: fear of *this* man; ***substantive man + phraseology***: I am such a man: *either master or missing*; ***substantive man + metaphorization***: man *of body and bone*; ***substantive man + subordinate definite component***: similar to the feeling of a man *who returned home from the solitude of the forest to the bosom of a large and eloquent family*. I. Franko uses the lexeme *man* meaning "person/man" in the model of the ***substantive man + adjective decent:*** although a Jew, but a *decent* man.

The analyzed concordance gives grounds to distinguish the lexeme **mister/pan** in the sense of "who held a privileged position in society, belonged to the affluent sections of the urban population, the intellectuals" in the following models: substantive *mister/pan* + single adjective (*local* mister/pan); substantive *mister/pan* + adjective form (handfuls of mister/pan *in furs*); substantive *mister/pan* + pronoun: (*our* mister/pan); substantive *mister/pan* + numeral: (*several more* misters/pans); substantive *mister/pan* + phraseology or metaphorization (Mr. *neither my brother nor my fiancé*).

Adjective compatibility of other masculine lexemes is less diverse: **small man/cholovichok**: substantive *small man/cholovichok* + single adjective (*little* small man), substantive *small man/cholovichok* + adjective form or phrase (small man/cholovichok *from the crowd*, small man/cholovichok *aged forty)*, substantive *small man/cholovichok* + subjunctive definite component (a small man/cholovichok *surrounded by a bunch of peasants*); **husband/man/muzh**: substantive *husband/man/muzh* + singular adjective (*future* husband), substantive *husband/man/muzh* + possessive pronoun: (*your* husband); **man/muzhchyna**: substantive *man/muzhchyna* + single adjective (*black mustached* man), substantive *man/muzhchyna* + pronoun (*which* man); **man/muzhyk**: substantive *man/muzhyk* + pronoun (*those* men); **man/khlop**: substantive *man/khlop* + single adjective (*ideal* man/khlop), substantive *man/khlop* + pronoun (*that* man/khlop), substantive *man/khlop* + adjective part of a compound predicate (man/khlop is *holy*); **guy**: substantive *guy* + single adjective (capable guy); **boy/ khlopchyna**: substantive *boy/ khlopchyna* + single adjective: (*weak* boy/khlopchyna); **boy/khlopchyk**: substantive *boy/khlopchyk* + indicative pronoun (*this* boy); **young man/parubok**: substantive *young man/parubok* + single adjective (*young* man/parubok), substantive *young man/parubok* + adjectival form (young man/parubok *under the mustache*); **young mister/panych**: substantive *young mister/panych* + singular adjective (*good* young

mister/panych), substantive young *mister/panych* + indicative pronoun (*that* young mister/panych). The lexeme **boy/khlopchysko** in "Cross-Paths" is used three times without adjectival characteristics.

I. Franko most often uses the lexeme **woman** in the meaning of "female person" in the attributive model of substantive *woman* + single adjective. The writer also used the lexeme **woman** in the following attributive models: substantive *woman* + possessive pronoun (*my* woman); substantive *woman* + phraseology, metaphorization, comparison: (woman, *God forbid*; woman *devil's seed*); substantive *woman* + application (*comedian* woman).

The lexeme **lady/pani** in the meaning of "a woman who held a privileged position in society" is implemented in the following attributive models: substantive *lady/pani* + single adjective (*kind* lady/pani); substantive *lady/pani* + adjective form (lady *of the house*); substantive *lady/pani* + pronoun (*your* lady/pani); substantive *lady/pani* + apposition (lady/pani *solonizantka*).

The adjective compatibility of other feminine lexemes is as follows: **woman/zhinochka**: substantive *woman/zhinochka* + single adjective: (*any* woman), substantive *woman/zhinochka* + possessive pronoun: (*my* woman/zhinochka), substantive *woman/zhinochka* + metaphorization, comparison: (woman/zhinochka *urban potion*); **wife/zhontsa**: substantive *wife/zhontsa* + adjective phrase (mister's "wife/zhontsa"); **young lady/pannochka**: substantive *young lady/pannochka* + single adjective (*young* lady), substantive *young lady* + adjective form (young lady *in mourning*), substantive *young lady/pannochka* + pronoun: (*my* young lady), substantive *young lady/pannochka* + subjunctive definite component (same young lady *as last year at the ball and on the street made such a strong impression on him*); **girl**: substantive *girl* + single adjective (*dear* girl), substantive *girl* + adjective form (*self-defined* girl), substantive *girl* + pronoun (*this* girl); **girl/divchynka**: *substantive girl/divchynka* + *single adjective* (*little* girl).

A comparative analysis of attributive pronoun models to denote the linguistic images of man and woman showed their different social status in the society of that time. The frequency of using indicative pronouns with lexemes to denote a man's language image demonstrates its significance and priority, while the attributive pronoun models with lexemes to denote a woman's language image indicate her dependent role, restriction of rights, belonging and subordination to man.

Cognition of man, understanding of the masculine and feminine mentality of our people is not possible without delving into the linguistic picture of the world, represented by the creative work of writers, including Ivan Franko. Kamenyar recreates the linguistic image of a man and a woman, traditionally formed for Ukrainian society at that time. The attributive compatibility of the analyzed concordance made it possible to see Franko's understanding of masculine and feminine virtues, among which the priority for man is reason, common sense and the ability to master themselves in a variety of situations, and for woman is gentleness, patience, tact, indulgence, delicacy, gentleness and not compete with people of the opposite sex.

The perspective of the research. Such linguistic research in the future will allow to study the features of linguistic means of depicting man and woman in the works of other writers, to characterize the individual author's picture of the world of Ivan

Franko and his idiosyncrasy, to compare statistical characteristics of the text "Cross-Paths" with similar data of other prose works, to identify the dynamics of growth or decline of language images of gender stereotypes, the degree of emergence of new words in the idiolect of the writer, etc.

References

1. Vasilev, A., Vasileva, I.: Text length and vocabulary size: case of the Ukrainian writer Ivan Franko. So Glottometr. **43**(1), 3–22 (2018)
2. Heather, J.: Coleman: Ivan Franko and his community. Can. Slavon. Papers **62**(3–4), 543–545 (2020). https://doi.org/10.1080/00085006.2020.1831195
3. Brickner, T.: Linguistic image of nature in Franko's prose. The dissertation for the scientific degree of the candidate of philological sciences on a specialty 10.02.01, the Ukrainian language (2020). https://lnu.edu.ua/wp-content/uploads/2020/10/dis_brikner.pdf
4. Wu, J.-F.: Impact of foreign language proficiency and English uses on intercultural sensitivity. Int. J. Mod. Educ. Comput. Sci. (IJMECS) **8**(8), 28–35 (2016). https://doi.org/10.5815/ijmecs.2016.08.04
5. Parsafard, P., Veisi, H., Aflaki, N., Mirzaei, S.: Text classification based on discriminative-semantic features and variance of fuzzy similarity. Int. J Intell. Syst. Appl. (IJISA) **14**(2), 26–39 (2022). https://doi.org/10.5815/ijisa.2022.02.03
6. Arya, C., Dwivedi, S.: Keyphrase extraction of news web pages. Int. J. Educ. Manag. Eng. (IJEME) **8**(1), 48–58 (2018). https://doi.org/10.5815/ijeme.2018.01.06
7. Mumtaz, D., Ahuja, B.: A lexical approach for opinion mining in Twitter. Int. J. Educ. Manag. Eng. (IJEME) **6**(4), 20–29 (2016). https://doi.org/10.5815/ijeme.2016.04.03
8. Panayiotou, C.: Extraction of poetic and non-poetic relations from of-prepositions using WordNet. In: IEEE Access, vol. 10, pp. 3469–3494 (2022). https://doi.org/10.1109/ACCESS.2021.3140030
9. Laporte, S.: Corpora, constructions, new Englishes a constructional and variationist approach to verb patterning. Stud. Corpus Linguist. **100**, 1–419 (2021). https://doi.org/10.1075/scl.100
10. Rovenchak, A., Buk, S.: Part-of-speech sequences in literary text: evidence from Ukrainian. J. Quant. Linguist. **25**(1), 1–21 (2018). https://doi.org/10.1080/09296174.2017.1324601
11. Lin, S.Y., Chen, H.C., Chang, T.H., et al.: CLAD: a corpus-derived Chinese Lexical Association Database. Behav. Res. **51**, 2310–2336 (2019). https://doi.org/10.3758/s13428-019-01208-2
12. Pollak, S., Gantar, P., Holdt, ŠA.: What's New on the Internetz? Extraction and lexical categorisation of collocations in computer-mediated Slovene. Int. J. Lexicogr. **32**(2), 184–206 (2019). https://doi.org/10.1093/ijl/ecy026
13. Buk, S., Rovenchak, A.: Simple definition of distances between texts from rank-frequency distributions. A case of Ukrainian long prose works by Ivan Franko. Glottometrics **46**, 1–11 (2019)
14. Vysotska, V., Holoshchuk, S., Holoshchuk, R.: A comparative analysis for English and Ukrainian texts processing based on semantics and syntax approach. In: Computational Linguistics and Intelligent Systems, COLINS, CEUR Workshop Proceedings, vol. 2870, pp. 311–356 (2021)
15. Stasiuk, L.: Computer sampling and quantitative analysis in exploring secondary functions of questions in speech genres of intimate communication. In: Computational Linguistics and Intelligent Systems, COLINS, CEUR Workshop Proceedings, vol. 2604, pp. 227–238 (2020)
16. Ljubešić, N., Logar, N., Kosem, I.: Collocation ranking: frequency vs semantics. Slovenščina 2.0: Empir. Appl. Interdiscip. Res. **9**(2), 41–70 (2021). https://doi.org/10.4312/slo2.0.2021.2.41-70

17. Bouso, T., San Segundo, P.R.: The British Sentimental Novel Corpus (BSNC) and the ROC-DDC alternation at the level of the individual. NJES Nordic J. Engl. Stud. **20**(1), 215–257 (2021). https://doi.org/10.35360/njes.659
18. Viana, V., Kirk, J.: Academic prose across countries. In: Čermáková, A., Malá, M. (eds.) Variation in Time and Space: Observing the World Through Corpora, pp. 283–320. De Gruyter, Berlin, Boston (2020). https://doi.org/10.1515/9783110604719-012
19. Kulchytskyy, I.: Quantitative parameters of some novellas by Roman Ivanychuk. In: Computational Linguistics and Intelligent Systems, COLINS, CEUR Workshop Proceedings, vol. 2604, pp. 89–105 (2020)
20. Shvedova, M., Von Waldenfels R.: Regional annotation within GRAC, a large reference corpus of Ukrainian: issues and challenges. In: Computational Linguistics and Intelligent Systems, COLINS, CEUR Workshop Proceedings, vol. 2870, pp. 32–45 (2021)
21. Shvedova, M.: The general regionally annotated corpus of Ukrainian (GRAC, uacorpus.org): architecture and functionality. In: Computational Linguistics and Intelligent Systems, COLINS, CEUR Workshop Proceedings, vol. 2604, pp. 489–506 (2020)
22. Hadzalo, A.: Analysis of gender-marked units: statistical approach. In: Computational Linguistics and Intelligent Systems, COLINS, CEUR Workshop Proceedings, vol. 2604, pp. 462–471 (2020)
23. Newman, M.L., Groom, C.J., Handelman, L.D., Pennebaker, J.W.: Gender differences in language use: an analysis of 14,000 text samples. Discourse Process. **45**, 211–236 (2008)
24. Buk, S., Rovenchak, A.: Online Concordance of Ivan Franko's Novel "Cross-Paths". http://ktf.franko.lviv.ua/users/andrij/science/Franko/concordance.html
25. Barabash-Revak, O.: Language image of a young man in Ukrainian folklore and ethnographic texts. The dissertation for the scientific degree of the candidate of philological sciences on a specialty 10.02.01, the Ukrainian language. L'viv (2009)
26. Levchenko, O., Holtvian, V., Dilai, M.: Statistical profiles of Ukrainian prose fiction: gender aspect. In: International Conference on Computer Sciences and Information Technologies, vol. 2, pp. 97–100 (2021). https://doi.org/10.1109/CSIT52700.2021.9648668
27. Stoller, R.J.: Sex and gender. In: The Development of Masculinity and Femininity, vol. 1, p. 400. Science House, New York (1968)
28. Humeniuk, I.: Gender markers in the English picture of the world. Wisdom **19**(3), 100–113 (2021). https://doi.org/10.24234/WISDOM.V19I3.506
29. Koban Koç, D.: Gender and Language: A Sociolinguistic Analysis of Second Language Writing. Futuristic and Linguistic Perspectives on Teaching Writing to Second Language Students, pp. 161–177. IGI Global (2021). https://doi.org/10.4018/978-1-7998-6508-7.ch010
30. Hussey, K.A., Katz, A.N., Leith, S.A.: Gendered language in interactive discourse. J. Psycholinguist. Res. **44**, 417–433 (2015)
31. Dydyk-Meush, H.: Combinatorics of the Ukrainian Language of the XVI–XVIII Centuries: Theory, Practice, Dictionary. Lviv (2018)
32. Dictionary of the Ukrainian Language. http://sum.in.ua

New Anglicisms in the Ukrainian Language: Social Internet Communication Context

Iryna Farion

Abstract The article reveals extracurricular factors of global anglicization and studies degrees of lexico-semantic adaptation of thematic new anglicisms in the Internet environments and presents their specific Ukrainian equivalents. Examples of new anglicisms (блог, троль, тролінг, квест) as magic tricks of modern Internet communication are given. Based on a sample of 100 anglicisms, their etymological nature is revealed with a reasonable concept of pseudoanglicism and the need to create a specific vocabulary in Internet environments. The results of studies are presented in tables (3), charts (8) and diagrams (3).

Keywords Anglicisms · New anglicisms · Barbarization · Internet communication area · Internet environment · Sociopersonal Internet field · Internet information context

1 Introduction

The beginning of the third millennium was marked by a massive influx of anglicisms into the Ukrainian language, which is caused by the leading role of English-speaking countries in world politics, in particular the United States and Great Britain, as well as the increasing openness of Ukraine to inter-state communication and the formation of an open media environment, in particular the Internet—'this final stage of intellectual colonization' [1]. Despite these linguistic and globalization processes, no one has ever managed to destroy throughout human civilization the natural aspiration of each nation to develop their ethnic-linguistic identity and oppose not only the socio-political expansion of foreign languages, but also cultivate the culture of their language in resistance to barbarization and, particularly in Internet communication. This in mind, the number of studies dealing with the problems of anglicisms

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in Ukrainian and other languages is increasing with the continuous process of anglo-barbarization of different languages, in particular Slavic or a group of Romance languages.

The first wave of significant penetration of anglicisms into the Ukrainian language falls at the end of the 19th–beginning of the twentieth century as a period of our active industrial and technological development [2]. However, the first stage of scientific study of anglicisms in the Ukrainian language dates back to the 1980s of the twentieth century and is represented by the works of Y. Holdovansky, where he addresses issues of their diachronic adaptation (innovation phase—initial use, virtualism—minor proliferation and neologism—generally recognized proliferation) and history of penetration into the receiving language [3, 4]. Consequently, his study has been transformed into a topical lexicographic work 'Dictionary of anglicisms' (2018) [5]. Lexical and semantic structure of anglicisms is studied by S. Oleksiienko, rightly observing that the moment of the first anglicism use determines its stylistic connotation [6].

Together with the further avalanche of English borrowings in the twenty-first century, the number of dissertations about this lexical layer grows: Popova [7], Styshova [8], Fedorets [9], Arkhypenko [10], Bytkivska [11], Lapinska [12], Maistruk [13], Yasynetska [14] and others, as well as numerous articles on this topic mainly on degrees of expansion of anglicisms, their lexical-semantic structure, syntagmatic-paradigmatic, pragmatic linkages and functioning, feasibility and prospects of entering the language system and the influence of extralinguistic factors, and also development of anglicism dictionaries.

Over the past four years (2019–2022) in European linguistics, the number of studies also grows on the process of borrowing from the English language, the status of anglicisms and pseudoanglicisms, their pragmatics and syntagmatics, adaptation to a particular language system. We will mention the context of Slavonic and Romance languages, because the first are genetically related to our study subject, and the second are vivid example of linguistic discussions about the place of new anglicisms in the language norm at the level of not only scientific, but also state institutions.

Polish linguistics, which began the study of English borrowings as early as 1960–1980, now tends toward the study of anglicisms in the field of corpus linguistics. The degree of borrowing valence, frequency of the phonetic, graphical and morphological adaptation, narrowing or expansion of the semantic meaning have been studied, and the number of the available specific synonyms has been measured. Simultaneously, the strengths and weaknesses of the corpus method of studying borrowings have been examined [15].

No less common is the thematic approach to the study of new anglicisms. For example, Alicja Witalisz focuses on the onomasiological principle of study of semantic field of LGBTQ+ and derivative lexical units, on the study of its sociolectal nature and the possibility of speech adaptation [16]. She analyzes the same semantic field, but in a narrower context of the morphological adaptation of the analytical lexical unit 'coming out' within the framework of synthetic Polish language [17] Czech linguistics emphazise the concept of pseudoanglicisms. Bozděchová Ivanaa and Klégr Aleš [18] delineate the terms of adaptation and neologisation

of borrowings and, therefore, by analyzing 516 anglicisms in the context of their semantic and morphological adaptation, prove the Czech language tendencies to neologisation processes and significant valence of pseudoanglicisms compared to the number of anglicisms borrowed without any changes. In particular, Chlebowski [19], having studied 435 lexical units of anglicisms and their derivatives on the pages of the journal 'Mladá fronta Dnes' and analyzed the frequency of their use, thematically divided them into: sports, music and subculture, transport and construction, economy and trade, living. Special attention is paid to that percentage analysis of hapax legomenons. On the other hand, Entlová [20] studies the semantic field of Covid-19, having divided English borrowings as domesticated lexical units and as non-adapted new anglicisms and classified them according to the etymological principle (Anglo-Latinisms, Anglo-Greekisms, Anglo-Romance words, Germanisms, etc.). Hence, the relationship of the source language and the degree of adaptation of borrowing at all language levels in the absorbing language have been studied. After all, in the same paradigm of adapting anglicisms in the receiving language at the phonetic-phonological, lexical-semantic and morphological-syntactic levels, but in comparative analysis with the Slovak language, conduct their study Gabriela Entlova and Eva Mala who, however, note the status of anglicisms as internationalistic one [21].

Slovakian linguistics focuses on the problem of standardization of new anglicisms, study of the attitudes and linguistic practices of different strata of society and linguistic institutions. Panocová [22] highlights the problem of purism and English new borrowings in the dialogue between scientific and governmental institutions (Jazykovedný ústav Crossed D sign udovíta Štúra Slovenskej akadémie vied), (Crossed D sign udovít Štúr Institute of Linguistics of the Slovak Academy of Science) and native speakers.

Both Serbian and Croation linguists do not bypass the challenge of new English borrowings. Croatian researcher Morić-Mohorovičić [23], having analyzed a number of electronic resources, focuses on the flow of new anglicisms in fashion terminology and classifies them according to the principle of domestication and adaptation: pseudoanglicisms, direct borrowings, partially translated words, borrowings with tranlation, semantic borrowing. Serbian scientist Klajn [24] processes basic models of borrowing, calquing and neologisation in modern Serbian language, taking into account linguistic and extralinguistic factors. The vast majority of anglicisms, including pseudoanglicisms (Anglo-Latinisms and Anglo-Greekisms), compared to a much smaller number of gallisms and Germanisms, is explained by the extralinguistic dominance of English as an international means of communication. Special attention is paid to derivative models of adaptation of borrowings inherent in the internal structure of the Serbian language.

In the Romance languages, on the one hand, puristic tendencies of academic institutions have long been known, and on the other hand—the wider society is involved in public discussions, even battles. Thus, French linguistics underlines the appropriateness/inappropriateness of inclusion of new anglicisms in dictionaries. Niklas-Salminen [25] consider official proposals of the Commission on Terminology and Neologisms (Commission générale de terminologie et de néologie) for the

dictionary «le Petit Robert de la langue française». Having included three semantic levels of the proposed lexical units (information space, audio-visual environment, culture and economy), the researcher segments new anglicisms and proposed French specific equivalents taking into account the form of their word-formative adaptation: compound words, derivatives, abbreviations, amalgam, apocope, etc.

The question is separately raised of the appropriateness of word-based or interpretative translation in the process of domestication of English lexical units. Walsh [26] offers comparative analysis of French native speakers in France and Quebec–the French-speaking province of Canada—against the rapid wave of English borrowings over the past decade. Based on the results of specially created questionnaire, the concepts of 'external' and 'internal purism' and so-called 'semi-purism' have been explained. The influence of extralinguistic factors has been worked out on the acceptance or non-acceptance of English borrowings. To conclude, an interesting comparative approach has been used by Duběda [27] resorting to contrastive comparison of English borrowings in French, Czech and German languages, but the Czech scientist restricts himself to purely phonetic adaptation.

Italian researcher Brecelj [28], having analyzed the body of the most read Italian newspapers Corriere della Sera and La Repubblica, distinguishes the semantic field of new anglicisms, which have gained unprecedented expansion in the Italian language since the time of COVID-19, and tracks the frequency of their use. The focus of the study is on specific equivalents and calquing processes. Similarly, studying the web pages of the newspaper Corriere della Sera and using a taxonomic approach, Gazzardi and Vásquez [29] suggest looking at new anglicisms from the media industry considering the category of reasonability/lack of reasonability. Furthermore, examples of hybrid borrowing or morphological syntax adaptation to a receiving language were identified and classified.

Another Italian researcher Pulcini [30] examined anglicisms within the broader category of internationalisms, paying special attention to the phenomenon of pseudoanglicisms, and therefore, resorts to etymological comparative comparison of newly arrived anglicisms and specific Italian equivalents, sporadically fixing their Romance origin. In this way, the problem has been raised of speakers' perception of international lexical units as the borrowed ones and lack of linguistic sense regarding their phonetic and morphological relationship with the Italian language. Our material quite confirms such an approach of the researcher and propagation of pseudoanglicisms in Internet environments.

After all, the problem of the invasion of new anglicisms does not bypass the Spanish philologists. Deeney and Beletskaya [31] compare the attitude towards new anglicisms of ordinary speakers and official scientific and research institutions, as the Royal Spanish Academy (La Real Academia Española) and language foundation Fundéu BBVA. Researchers analyse the outward influence of extralinguistic factors on categories of openness/closeness of language and compare the social and linguistic manifestation of purism. The atypical semantic field is at the core of the work of Luján-García [32] where, from a functional perspective, the emergence and spread of anglicisms from the gastronomy industry have been studied.

The object of our study is a random selection of 100 anglicisms used in Internet environment covering different thematic groups and reflecting pragmatic syntagmatic relationships. We explore their social pragmatism, ethymological nature, which simultaneously reveal the phenomenon of psedoanglicisms with Latin, less often Greek and other etyma.

The subject of the study are anglicisms as markers of certain Internet communication environments with varying degrees of adaptation of anglicisms, their perception, pragmatic syntagmatic relations and, most importantly, search of specific Ukrainian equivalents to them as a method of construction of own, rather than a borrowed, reality.

In this study we use onomasiological method, studying the foreign nomination process as a synthesis of extralinguistic and intralinguistic factors, immersed in subjective (often false) representations of Ukrainians about things and phenomena lying in the heart of nomination. The substitution and renaming of concepts are often due to different socio-cultural and psycholinguistic background in the source language and the absorbing language, as well as politically biased interpretation of the Anglo-American realities in Ukraine.

2 Research Material and Methods

The methodological basis for the analysis of anglicisms in the Ukrainian language is a balanced language policy model implemented in:

(a) phonetic, word-formative and grammatical learning of borrowed words with the consequence that their non-specific origin is established only by means of etymological analysis, and not, for example, a dictionary of foreign (borrowed) words (тренінг – вишкіл, спікер – речник);
(b) paradigmatic syntagmatic inclusion of borrowings in the absorbing language (топові доповідачі – найкращі доповідачі), which makes it possible to identify whether synonymic, antonymic or paronymous relations with other categories are available or missing, that is, whether the lexical unit becomes ‘a member of the so-called hyper-hyponymic lexical associations’ (subsumption relations);
(c) replacing borrowed words with synonyms created on own land, that is, unreasonable doublet reflection (булінг – цькування, драфт – проєкт, план, начерк);
(d) ethnocultural need to borrow the concept itself with a word that expands (possibly, enriches) the conceptual basis of the absorbing language, according to L. Bulakhovskyi, ‘qualitative’ (not quantitative—I. F.) borrowing’: інтерфейс – взаємодійник [33]. In such circumstances, there will be a law of balance of foreign and specific words that will protect the language from Anglo-barbarization (Fig. 1).

We interpret Anglo-barbarization as linguistic social pathological phenomenon that not only contradicts the law of equilibrium of foreign and specific words in

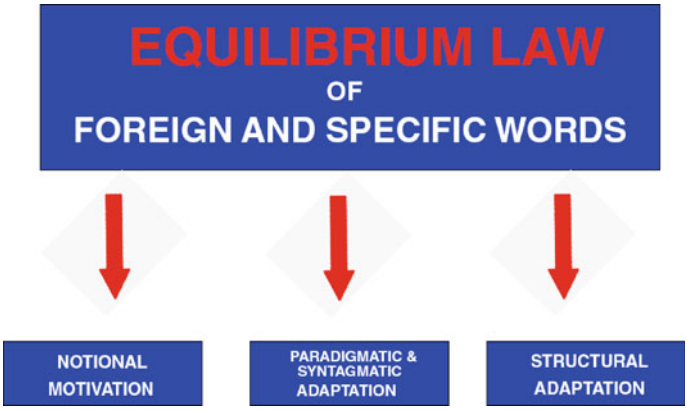

Fig. 1 Law of equilibrium of foreign and specific words

phonetic, word-formative and grammatical adaptation, but also demonstrates the language policy of national defeat, in particular, in the Internet information environment. The Anglo-barbarization inevitably generates an opposite phenomenon, which is called anti-anglicism. Anti-anglicism is a system of extralinguistic and intralinguistic factors for the actualization of own language resources to preserve its culture and specificity [33]. Integration into the so-called globalized world with positive result for its country is possible only with conditional specific information space in the Internet area.

Language as a reflection of reality (language world) inevitably absorbs foreign lexical units, transmitting opposition relations between barbarization as an language alienation and borrowing as its enrichment. In its turn, a subvariety of the barbarization phenomenon is Anglo-barbarization with the opposition of Anglicism—anti-anglicism, which is shown below in Fig. 2.

3 Results

The proposed sample of anglicisms is taken from the Internet environments of the Ukrainian information space concerning the most common communication areas implemented through lexical-thematic groups, presented in the proposed Table 1.

Given the varying degrees of lexical semantic expansion, the proposed anglicisms (or pseudoanglicisms) are divided into three main groups: barbarization, expanded borrowing, resonable borrowing:

1. Barbarization is borrowing with an existing and unclaimed equivalent in translation dictionaries, as well as with a new specific equivalent, its search and approbation (67%).

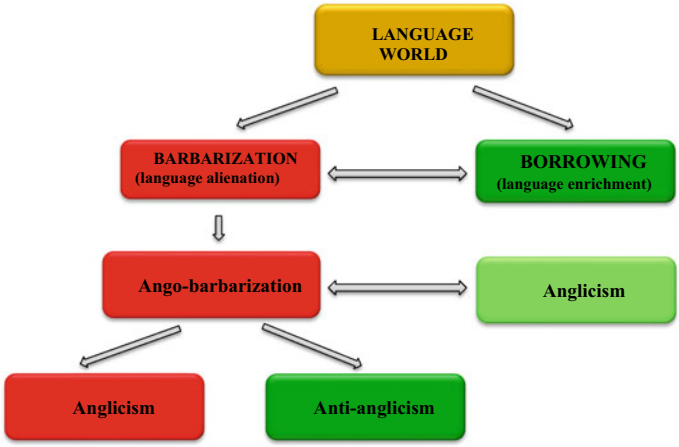

Fig. 2 Borrowing as foreignization or enrichment

Table 1 Lexical-thematic groups of anglicisms in the Internet communication areas

Internet communication area	Anglicism examples
Educational	булінг, бьордвотчер, воркбук, воркшоп, драфт, експлейнер, квест, коуч, лепбук, неймінг, скаут, скіл, софт-скіл, хард-скіл, сторітейлінг, тімбілдінг, тренінг, тьютор, фасилітатор, хомінг, хоумскулінг, ментор
Cultural	байопик, буккросинг, букпітчинг, гол, івент, кросворд, лонглист, хорор, фікшн, нон-фікшн, роуд-шоу, спойлер, спорт, тизер, футбол, хедлайнер, чейнворд, шорт-лист
Economic	інфлуенсер, кешбек, оншор, офшор, ребрендинг, стартап, стейкхолдер, фрилансер
Media	дайджест, кейс, медіа-кіт, моніторинг, подкаст, прес-кіт, тренд, форсайт, трафік, фактчекінг, фейк, хайп, білборд
Networking (Internet)	блог, бот, влог, дудл, контент, мем, меседж, онлайн, офлайн, сайт, стикер, тролінг, хейтер, чат
Everyday	аутфіт, дедлайн, крафт, лайфхак, лук, мікс, секс, топ, факап, фрик, хаб, пазл, чек-ліст, челендж
Sociopolitical	афіліація, аб'юз, бустер, гей, гендер, камінг-аут, локдаун, прайд, флешмоб, харасмент, спікер

2. Expanded borrowing is the possibility of replenishing the synonymic row through synonymic shades in meaning and nomination of a new term in the absorbing language (14%).
3. Reasonable borrowing—author's innovation in English language (and simultaneously, new reality in the absorbing language), which we call personomization, and anglicisms (or Anglo-Americanisms)—personoma (19%).

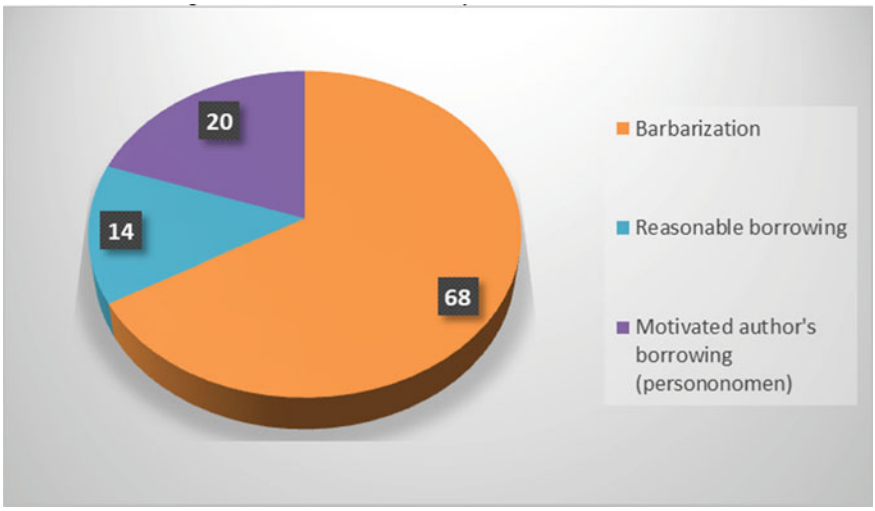

Fig. 3 Classification of anglicisms on the principle of expansion

Percentages, in particular, the highest number of borrowings at the level of barbarization (67%), less expanded borrowings (14%) and only 19% of reasonable borrowings due to lack of the relevant concept or reality in the absorbing language, indicate a very low level of using resources of absorbing language and Internet users' bowing down before foreign unreasonable vocabulary (Fig. 3; Table 2).

The author's anglicisms include the following: crossword, lifehack, bot, blog, vlog, soft skills, podcast, stakeholder, meme, freelancer, startup, spoiler, case, bookcrossing, coming out, harassment, birdwatching, storytelling, flashmob, gender, sex, lapbook, which are 22% of the proposed sample of anglicisms, what we have learned from the information Internet environment. From the sociolinguistic point of view, as discussed below, such vocabulary expands the conceptual circle of Ukrainian reality and encourages the creation of specific innovations taking into account the uniqueness of the Ukrainian-speaking reality (Fig. 4).

We will illustrate the Internet information context of the functioning of individual anglicisms (or pseudoanglicisms) relating to the three different analyzed groups of lexico-semantic learning (barbarization, expanded borrowing, reasonable borrowing—personononomenon, personomination): чат and pseudoanglicism квест with derivatives веб-квест, квест-перформенс (barbarization)—borrowing with an obvious and unclaimed equivalent in translation dictionaries; троль, тролінг—expanded borrowings as an opportunity to replenish the synomymic row due to the conceptual absence in source language and synonymic shades in meaning; блог and its derivatives—as an author's borrowed innovation.

Table 2 Lexico-thematic groups of anglicisms in the Internet communication area

Degree of expansion of anglicism (pseudoanglicism)	Anglicism (pseudoanglicism)	Ukrainian equivalents
Educational	аб'юз	насильство
	аутфіт	стрій
	афіліація	належність
	байопик	біографічний фільм
	білборд	рекламний щит (дошка)
	букпітчинг	фільмоподача
	булінг	цькування
	воркбук	робочий зошит
	воркшоп	робітня, майстерня
	дайджест	огляд
	дедлайн	рече(и)нець
	драфт	чернетка, начерк, ескіз проєкт
	дудл	малюнок, каракулі
	експлейнер	пояснювач
	івент	подія
	інфлуенсер	впливовець
	спікер	речник
	квест	шуканка
	кейс	випадок
	кешбек	повернення коштів
	контент	вміст
	коуч	наставник, виховник
	крафтовий продукт	домашній продукт
	пазл	складанка
	локдаун	закриття, карантин
	лонглист	довгий список
	лук	стрій, вбрання, вигляд образ
	прескіт, медіякіт	інфодані
	меседж	повідомлення, посил
	ментор	наставник
	мікс	суміш
	хорор	жахи (фільм жахів)
	моніторинг	відстеження, спостереження

(continued)

Table 2 (continued)

Degree of expansion of anglicism (pseudoanglicism)	Anglicism (pseudoanglicism)	Ukrainian equivalents
	неймінг	назовництво
	нон-фікшн	нехудожня література
	фікшн	художня література
	онлайн	в мережі
	офлайн	наживо
	ребрендинг	оновлення
	роуд-шоу	мандрівний показ (презентація)
	скаут	пластун
	скіл	навичка
	софт-скіл	суспільні навички
	хард-скіл	технічна навичка
	стикер	наліпка, наклейка, етикетка
	тизер	дажнилка
	тимбілдінг	згуртування
	трафік	потік, рух, обсяг
	тренінг	вишкіл
	тьютор	наставник, вчитель, виховник
	факап	провал, облом, невдача, халепа
	форсайт	передбачення
	фактчекінг	перевірка фактів
	фасилітатор	керівник
	фейк	брехня, неправда
	фрік	дивак, чудасій, химерник
	хаб	центр, осередок, вузол
	хайп	галас, інтерес, захват
	харасмент	домагання
	хейтер	ненависник, ненавидець
	хомінг	повернення додому
	хоумскулінг	домашнє навчання
	хедлайнер	зірка, герой, улюбленець, кумир
	чат	бесіда
	чек-ліст	перелік, список

(continued)

Table 2 (continued)

Degree of expansion of anglicism (pseudoanglicism)	Anglicism (pseudoanglicism)	Ukrainian equivalents
	челендж	виклик
	шорт-лист	короткий список
Expanded borrowing	бустер	підсилювач
	гей	збоченець
	гол	–
	кейс	набір
	офшор	безподаткова територія
	оншор	оподаткована територія
	прайд	– (хода)
	сайт	сторінка
	спорт	змаг
	топ, топовий	найкращий
	кейс	набір
	тренд	напрям, тенденція, мода
	троль, тролінг	–
	футбол	копаний м’яч
	чейнворд	–
Reasonable author’s borrowing (personononomen)	блог	
	бот	
	буккросинг	книгообіг, книгомандри
	бьордвотчинг	птахоспостереження
	влог	–
	гендер	соціостать
	камінг-аут	зізнання
	кросворд	хрестиківка
	лайфхак	навід, порада, підказка, лазівка
	лепбук	книжка-вкладанка
	мем	
	подкаст	передача, запис, студія
	секс	любощі
	спойлер	шкідник, капосник, паскудник
	стартап	запуск, почин
	стейкхолдер	зацікавлена сторона, користач

(continued)

Table 2 (continued)

Degree of expansion of anglicism (pseudoanglicism)	Anglicism (pseudoanglicism)	Ukrainian equivalents
	сторітелінг	оповідки, казки, байки, новелетки
	флешмоб	раптівка, попис
	фрілансер	вільнонайманець
	харасмент	домагання

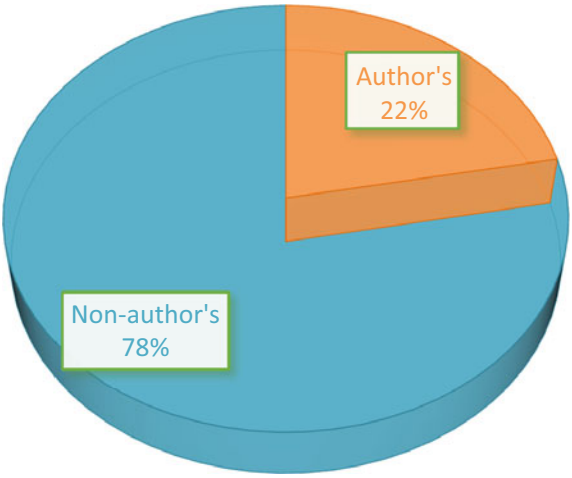

Fig. 4
Anglicisms-personononomena

3.1 Чат

An anglicism чат has become a common lexical unit in Internet environments identifying rapid exchange of text (so-called вебчати), voice messages and video chats between Internet users in the same time, without delay. The main difference between chat and forum is to make a chat in real time, at this moment, without delay. Chat is also the software itself that allows you to carry out network communication.

In English, it is a multivalent and multicontent word: chat [tʃæt] n1. ‘small (friendly) talk; chatter; prattling, babbling’; a friendly ~ friendly talk; a pleasant ~ pleasant talk; a ~ about speak about; a ~ between speak between; a ~ with speak with; to have a ~ have a talk, have a chatter; 2. Activ. ‘asuredness, impertinence’; 3. pl mining. ‘mining waste’; 4. conv. ‘louse’; chat [tʃæt] v (past and p. p. chatted, pres. p. chatting) ‘relaxed talk, babble, gossip’; to ~ about speak about; to ~ with speak with [34].

According to one version, the word came from the late Middle English verb chatt(e) of 1400–50 as an abbreviation from chatter: chater n 1. ‘chatter, babbling’; 2. ‘prattling, noise; clack; джерґотання’; 3. ‘дзюрчання’; 4. ‘деренчання’; 5. ‘стукіт,

клацання'; 6. tech. 'вібрація, дрижання'. In the same meanings, the word is used as a verb [35]. According to another, no less likely version, derived from onomatopoetical meanings, the lexical unit originated as an echoism of a bird from the thrush family [36]. Compare with the Dutch koeten 'базікати', the Danish kvidre 'щебетати, цвірінькати' [37].

So, as we see, the Internet space is introduced with the ancient multivalent and multicontent English word with its first meaning, with which it has been enthroned in Internet communication. So, what prevents from using the Ukrainian word, for example, бесіда, as an equivalent to this anglicism?

In the Ukrainian language, бесіда, и, f. 1. 'conversation with someone'; 2. 'report, message on any topic with further exchange of thoughts; interview'; 3. conv. 'partying at someone's; banquet. 4. conv. 'friends, company'. 5. activ. 'language, speach' [38].

This word is still known in Old Slavonic language with meanings: 1. 'word, speach, conversation; communication style'; 2. 'sermon' [39], which comes from Old Church Slavic *besěda, formed from an adverb bez 'outside' and noun sěda 'sitting' with an initial meaning 'sitting outside', later 'meeting, which, subsequently, on this basis has gained meaning 'conversation', 'communication' [40]. The Dictionary of Old-Ukrainian language of 14th–fifteenth centuries presents this lexical unit only with the meaning 'have conversation, converse (with someone)' [41], Yevhen Tymchenko—only with the meaning 'party, celebrant' [42], instead, the Dictionary of Ukrainian language (СУМ) 16th–the first half of seventeenth century contains as many as five meanings of this word, among which the first is 'speach, language, words' [43]. To conclude, over the centuries, there has been an expansion of the semantic structure of this word with the establishment of the main meaning—the name of the communication process. Given this, there is every reason to expand the meaning of this word for communication on the Internet.

It is no less important to remember that there are more than 80 synonyms in the Ukrainian language to the word розмова, the most famous of which are: базікання, балаканина, балачки, баляндраси, бесіда, варнякання, говорільня, гутірка, ляляканння, мова, пас(ш)талакання, переговори, перемови, поговори, річ, розмовини, теревені, траляляки, шушуканя, etc. [44].

Alternatively, in the Ukrainian language, чатувати means guard, watch someone (or something), waiting impatiently or waiting for the appearance of someone (something) [38] (Fig. 5).

3.2 КВесТ. Web-КВесТ. КВесТ-ПерфорМаНс

In the Internet resource, we read about the new educational project by the New Ukrainian School (NUS): 'One of the academic concepts of the NUS is interactive learning <…> The project 'Friendly School' offers to consider квести as an effective form of learning at home …», where they explain this concept: 'Квест is a game during which you need to find a solution for riddles and perform a number of tasks to

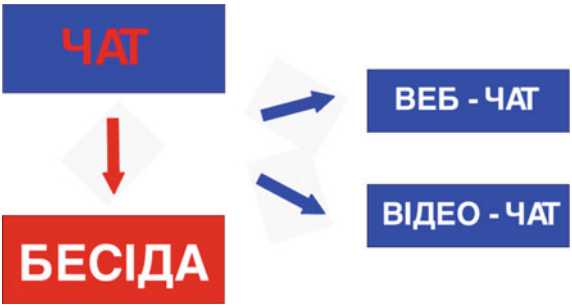

Fig. 5 Lexical unit чат, its derivatives and Ukrainian equivalent

achieve the goal. This format of classes allows you to actualize the educational material, to train logical thinking, quick reaction and engage in children an enthusiasm of researchers and discoverers' [45].

Therefore, they further suggest varieties of квестів, the name of one of which is presented without any translation at all in English language in graphically non-adapted and untranslatable form as the barbarism—escape room with the interpretation of 'when you need to perform a number of tasks in a certain time to get out of the room', where escape [ɪˈskeɪp] is a multivalent noun and a verb with the basic meaning of 'втеча', 'порятунок, визволення', 'утікати', 'уникати' [34]; hence, квест in reality is: 'when events unfold in the real world, there are no spatial restrictions (or they are very conditional). A variation is квест-перформанс, where, in addition to players, there are actors-characters that help to get better into the atmosphere, play the plot and reveal the theme more interestingly, where an anglicism was used again with Latin stem performance [pəˈfɔːməns] n with the main meaning of 'виконання, вистава' (театральна) [34] (comp. with Latin perfectus, meaning the action completed in the past prior to speech with the action result at the moment of speech, on the basis of which the meaning of action as a performance has developed in the English language); as well as barbarism-centaur, when graphically non-adaptive (Latin) and untranslatable anglicism WEB-квест—where 'all interactions between participants are transferred to the virtual space' (eng. web in the meaning of 'net').

Can't those four words (or word combinations)—квест, escape room, перформанс, web-квест be heard in the Ukrainian language by our children in the Ukrainian school, which had barely escaped from Moscow's paws?

In English, quest [kwest] is both a multivalent noun and a verb: n1. 'search; searching; inquiry'; 2. poet. 'sought object'; 3. hist. 'search of adventure' (in novels); 4. 'questioning'; 5. 'collection of donations' (in church); quest [kwest] v 1. 'search, chase'; 2. 'seek game' (for dogs); 3. 'search for food' (for animals); 4. 'collect donations' (for charity) (in Catholic churches) [34].

Hence, the derivative multivalent noun and verb question with the main meaning 'запитання' and 'запитувати', 'допитувати', 'опитувати' [34]. However, ethymologically this anglicism reaches the Latin language: quaestor < quaero 'шукаю, розшукую', where ancient borrowing квестор means 1. 'in ancient Rome, an appointed official: consular assistant in financial, judicial, administrative matters';

2. ‘in parliaments of some countries, administrative unit deputy’; 3. ‘police rank in Italy’ [46]. That is, we have an anglicism indeed.

This lexical unit is fundamental to the creation of phraseologism quaestio juris – liter. питай / приймай рішення з огляду на право; legal term referring to the investigation of a criminal case in accordance with the determination of the composition and gravity of committed crime or quaestio facit – liter. питай / приймай рішення відповідно до події, що сталася; legal term referring to the investigation of the fact or actual course of events at the time of commission of a crime [47].

That is, the basis of Latin is the concept of ‘шукати’, on the basis of which the additional English meanings have developed. It will perfectly serve for the emergence of the Ukrainian innovation instead of, as we found out, pseudoanglicism квест as шуканка [48] by analogy to збиранка < збиратися, гулянка < гуляти, співанка < співати, копанка < копати, etc.: search, find the right answer, as during the game, teams solve logical problems, search on the ground, build optimal travel routes, search for original solutions and clues. After completing another task, the teams move to the next one. The team that has completed all tasks faster than others wins.

At some point, an outstanding Ukrainian linguist, the founder of the history of the Ukrainian language, Pavlo Zhytetskyi having analyzed the linguistic apostasy of Ukrainians in the eighteenth century noted: ‘This is how in a gradual manner the life of the Ukrainian people was reconstructed into a new setting. Its old ideals, connected with the name of the Cossack, the defender of the people’s will, had lost their attractiveness, strength, became simply obscure for new generations. In such an age, self-interest is usually put in the forefront, and the pursuit of material well-being gains an advantage over every social impulse’ [49]. The scholar notes that this had its inevitable manifestation in speech. In particular, prince O. Bezborodko (1747–1799) called this new ‘Ekaterina’s’ generation as ‘firchik’ and ‘shtatik’, who changed in German clothes and had become such that one could say of them: not a warrior in the field, not a master in the house’ [49]. That is, this is such a transitional generation, which at the beginning wore Cossack’s zhupan, but under political pressure changed it into German clothes, and now changes into English ‘wording’ (Fig. 6).

Fig. 6 Lexical unit квест, its derivatives and Ukrainian equivalent

3.3 Троль, Тролінг

The Internet environment is unthinkable without the word троль, тролінг, which means ‘posting on the Internet of extraneous, non-thematic (on forums, news groups, etc.) provocative messages to cause conflicts between participants, insults, empty rhetoric or manipulation of political views, etc.’ (5).

The main goal of тролінгу as a process is not only to attract attention, but to disrupt a constructive discussion, lead it in another direction, etc. In short, this is what corresponds to our usual Latinism провокатор (provocator ‘who challenges’)—instigator [46].

In modern English usage, тролінг can describe the fishing technique by slowly pulling a jig or hook from moving boat, whereas тралення generally describes the commercial act of moving the fishing net. Early non-Internet-slang use of тролінгу takes place in military affairs: until 1972, the term ‘тролінг для МіГ’ was documented by US Navy pilots in Vietnam [50].

The word троль first appeared in the Internet viewpoint in the late 80s of the twentieth century, where it was used relatively innocently to expose the newcomer (new Internet user) on forums and bulletin boards. Тролінг usually was about a stupid question or an intentional error to check whether users would react to such a bait [51]. In other words, a sort of innocent mocking or joking as an evil ridiculing or gibing [38]. The Oxford Dictionary in this meaning recorded this word since 1992 [50].

In this way, we observe the metaphorical transfer of the meaning of the English word troll from fishing, where a bright tin can lure fish, to the process of deliberate incitement and even mockery of people in an Internet environment, where the words like tins are thrown to bring the discussed problem into emptiness. From here came the phraseme не годуй троля, that is, do not respond to his dumps and jigs.

In the first meaning, troll I. n is 1. the stanzas that the singers perform alternately’, 2. fish. ‘lure’ (shiny metal plate attached at the end of the fish line as jig for fish [38]); in the meaning of the verb: 2. v 1. ‘sing’ (beginning alternately), 2. ‘ troll fishing’, 3. ‘roll, spin’; ‘walk, take a walk’ (end of the nineteenth century), ‘roll from side to side’ (beginning of the 15th century) supposedly comes from the Old French hunting term troller ‘wander, hang about in search of fun’ (in modern French—trôler), further—from the German (compare with the Old German trollen ‘mince’), further—from Proto-Germanic *truzlanan.

It looks like it combines troll (v) ‘fishing with a fishing line’ (it was this meaning that arose as a result of the confusion with the word trawl ‘drag, trail’, originating from the Dutch tragelen, further—from Middle Dutch traghelen ‘drag’, traghel ‘trawl’, further—from the Latin tragula ‘trawl’) and troll (n) ‘troubled little devil living underground’ [37].

However, the use of this word in the Internet environment is reinforced by the meaning of another word borrowed from Scandinavian mythology to English language, which created a homonymous row: troll II. n scand. myth. троль [52]; ‘an imaginary very small or very large creature from the traditional Scandinavian

mythology with magical powers living in the mountains or caves'; 2. 'an intruder leaving an annoying or abusing message on the Internet' [53].

This homonymous meaning of a noun troll in the meaning of an ugly dwarf or giant reaches 1610 and comes from the Old Scandinavian word troll, which means 'giant' or 'demon' (< Gr.daimōn 'Divinity, spirit', in the Christian religion—evil spirit, devil), inhabitating dungeons or caves [54]; 'supernatural being in Scandinavian mythology and folklore' comes from the Old Scandinavian troll 'a huge being of no kind human, evil spirit, monster'. Some suggest that the word was originally used to refer to a creature that walks awkwardly and comes from the Proto-Germanic *truzlan, truzlanan (see troll(v) below). However, it seems that it was a general word for supernatural (compare with the Swedish trolla 'to charm' and the Old Scandinavian trolldomr 'witchery') [53].

This word has become the universal definition of all evil cretures. Moreover, the Norwegian word 'magic, witchery' also has the root 'troll': 'тролльскап' (trollskap) [55].

So, mythologically, trolls are the devilry, meaning evil spirits, demons personifying all devilish in one person. In our Ukrainian mythology (or demonology), there was 'noon devil'—полудниця, 'devil in the yard'—домовика, 'longhair devil'—лісовика. All together they are giants or spirits of different diseases that obcess people and animals. There are also 'white devils' living in the upper world as opposed to underground devils—'fears' [56].

The devil was also the Black God—the essence of evil, dark forces, death. Devils were imagined as ugly creatures with pig's snouts, long ears, tails, burning eyes. And one of the traits of trolls are long noses. Our devils snort, howl, wail; misdirect travellers, lead the unfortunate into mud, impassable wilds, push to the water-hole, etc., in other words, bait a trap. By contrast, trolls eat meat, often eat people, have respect for money, are desirous of human women, may also be kind, but are afraid of the light, on which they turn to stones [55, 57].

Interestingly, one of the etymologies of lexical unit devil, as also the second meaning of the English word troll, is related to the term 'shine', which means 'to lure, tempt': Old Slav. бѣсъ < Proto-Slav. bĕsъ < *boids- (<іє. *bhoidh-), obviously related to bojatisę 'to fear', which is related to Lith. baisà 'fear', baisus 'terrible, nasty', etc. to Indo-Eur. *bhōs- 'to shine, give light' and linking with Old Ind. bhāsati 'shines', bhāsā 'light, shine' [40].

There are synonyms that relate to troll: giant, gnome, demon, goblin, dwarf, monster, kobold [54].

With this foreign-language 'devilry' we will primarily join the word-formative synonyms of specific lexical unit devil and its content derivatives: бісеня, біситель, бісиха, бісиця, бісурка, бісовщина, бісота; бісити, біснуватися, добіса, достобіса, забісований [40], бісенятко, бісик, бісило, бісище, бісовило, бісяка [44]. We have 136 lexical synonyms to біс according to the dictionary of O. Vusyk (among them are also the word-formative derivatives), the most common of which are: чорт, антипко, антихрист, болотяник, вельзевул, вернивода, гаспид, демон, диявол, дідько, домовик, злодух, идол, курдуплик, куцак, куций, куць, лихий, лукавий, луцифер, нехрист, нечистий, огнянець, пекельник, рогатий, сатана,

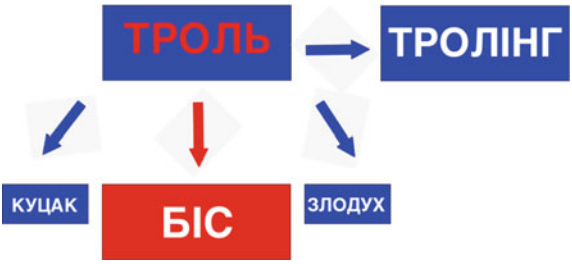

Fig. 7 Lexical unit троль, тролінг and their Ukrainian equivalents

триклятий, щезник, яропуд [44]. So, the spread of new anglicism троль and derivatives тролінг (and grammatically adapted тролити) in the Internet environment is caused not only by the metaphorical transfer of one of the meanings of anglicism troll as to lure fish during small jig fishing, but also the homonymous lexical unit troll borrowed from Scandinavian mythology with the main meaning of demon whose function is the also temptation and attraction of people to evil. As we see both mythologically and lexically, and ethymologically, lexical unit троль is not as innocent as the very disgusting process of trolling in the Internet.

As for our direct equivalents to trolls, both in meaning and origin (least in function), the nearest one is lexical unit біс (with all the word-formative wealth) and its derivatives біснуватися, біситится. We believe that, given the mythological origin of the word troll as a symbol of Scandinavian culture, it can expand (but not replace!) our rich row of synonyms to the word біс (Fig. 7).

3.4 Блог. Блогер

One of the most common anglicisms in the Internet environment is блог. As evidenced by lexicographical sources, blog [blɒɡ, amer. blɔːɡ blɑːɡ] 1. n ‘blog, Internet diary, weblog’; 2. v ‘do blog, blogging, write in a web diary; keep a web diary’ [58]; regularly updated website or web page, usually by a single person or small group, written in an informal or colloquial style, derrived from the abbreviation that emerged in the 1990s, weblog [59–62].

In the English language this lexical unt originated by way of composition and abbreviation (apocope by using apheresis): web ‘net’ + log ‘journal’ → [we]blog < blog, where lexical units web and log are multivalent [34].

Interestingly, according to the ethymological dictionary, the word blog existed in English as early as 1860 as a noun with meaning of ‘servant boy’ and as a verb with a meaning ‘to inflict defeat’ [63].

Perhaps none of the lexical units form near themselves such a multifaced sociopersonal Internet field and emergence of social platforms that have become a symbol of the 3rd millennium, namely Google, YOUTUBE, Facebook, Twitter, Instagram, Vk, TikTok, etc. There everywhere reigns blogger with its blog. In our thinking, the systematic narrator from the network for everyone’s liking (Fig. 8).

Fig. 8 Sociopersonal Internet-field of blog

If Ukrainians, primarily journalists, at first, in the newly formed social media and Internet media, called their columns of systematic written messages—journals (Taras Shevchenko also called his famous Diary—the Journal, where French jour 'day', literally, journal is a 'daily paper'—[46]), with the intense and rapid development of the Internet at the turn of the millennium, French journal gave way to the English blog, which was preceded by a composite weblog.

The history of the emergence of reality and word.

According to the most sources, the lexical unit weblog was first used on December 17, 1997 by an American from Ohio Jorn Barger—an editor of the early first blog Robot Wisdom. He, being wedded to computer, programming, mathematics, artificial intelligence and James Joice, created the first page of the web, where there were links to other pages devoted to the problems of his brainchild Robot Wisdom. So, he wrote about his worldview and interpretation of artificial intelligence for a decade, until Robot Wisdom really changed the way the world communicates.

As to collect interesting things from all over the world and write about them in the net—open to the world—was a new idea, he used a lexical unit Robot Wisdom Weblog for the 'journal in the network'. For an outstanding services in the development of the Internet, he was awarded the Web Innovator AwardsCNET as to 'the seer who changed the face of the Internet in 1998', 'set the tone for a million of future blogs' and created a blogosphere [64, 65]. However, there is another opinion that in modern sense, the term was first used in the title of the report by G. Raikundalia and M. Rees 'WebLog: exploiting the Web use interface for document management in electronic meetings' at a scientific conference in August 1995 [66].

Further lexical unit weblog spins are associated with the American Internet user Peter Merholtz, who in 1999 in his own Internet diary Peterme.com just for a laugh, as a omoform creation, divided and shortened this term to we and blog: 'we blog'.

Subsequently, Evan Williams, one of the co-founders of the Pyra Labs company, which is considered the creator of the blogger service, used the term blog as a noun and a verb to blog (in the meaning 'to publish a web log or make entries in a web log') and created the term blogger (Ukr. блогер) [67].

An English word-formative derivative blogosphere also has its own author (by analogy with atmosphere, stratosphere, etc.). This word was first used as a joke in 1999 by Brad Graham, who was thinking about the future of online communication

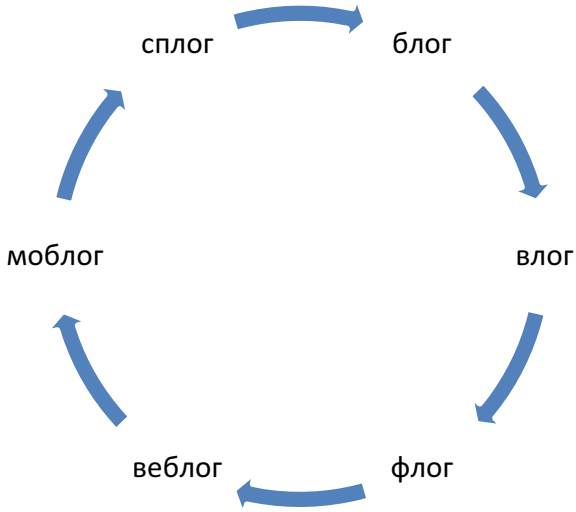

Fig. 9 Word-formative chain of lexical unit веблог: блог, влог, флог, сплог, моблог

and predicting the emergence of millions of blogs: 'Goodbye, cyberspace! Hello, blogiverse! Blogosphere? Blogmos?' [68]. The common usage of this term was put by William Quick in 2002 to denote the intellectual cyberspace occupied by bloggers [69] (Fig. 9).

Word-formative derivatives

If, according to the study of I. Andrusiak, in the English language, there are 76 terms with the forming basis—morpheme blog-, then in the Ukrainian language, their number is also considerable and indicative. This indicates the adapted derivative relationship of this lexical unit and reasonability of its borrowing in our language:

блогер, блогінг (the process of creating online diaries, i.e. blogs, and the name of the personal diary itself posted on the web page with the posts put in chronological order), блогерство (blogging activity), блогувати, блогосфера, відеоблоги (YOUTUBE platform), блогінг-платформи (by popularity 'Google' (1st place), 'Youtube' (2nd place), 'Facebook', 'Twitter', 'Instagram', 'Vk', etc.), мікроблоги (Twitter, Instagram, Vk, TikTok platforms), лайфстайл-блоги (about personal lifestyle), блогкасти (audio programs), as well as сплоги (spam blogs), флоги (paid promotional recordings posted as a personal impression), влоги (diary with video materials), моблог (filled from mobile). No less developed in our language are the syntagmatic connections with the formative word блог: блогерська діяльність, сфера блогерства, автор блога, etc. [70] (Figs. 10 and 11).

Therefore, it is impossible to avoid the anglicism блог and a certain part of its derivatives, because it is an Internet reality that has arisen outside the territory of Ukraine with its own conceptual base, although, of course, it does not make sense to withdraw from circulation the forgotten and adapted French word journal and the specific diary as the stairs in discovering the virtual world.

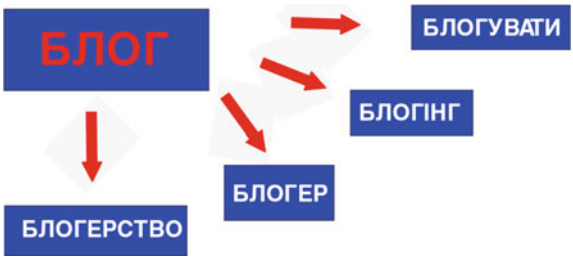

Fig. 10 Family of words from lexical unit блог (suffixation)

Fig. 11 Family of words from lexical unit блог (composition)

In addition to the degrees of lexico-semantic mastery of anglicisms and their social context in Internet environments, no less illustrative is the etymological analysis, allowing to reveal their origin resulting in a separate subgroup of pseudoanglicisms. Their inner form reaches primarily the Latinisms (37%) and to a lesser extent, other stems, which can be seen below in the Table and diagram. At the same time, the way these words get into the Ukrainian language through the English-speaking world justifies their name as pseudoanglicisms (Table 3; Fig. 12).

4 Conclusions and Practical Recommendations

At the heart of our study is an indicative sample of 100 anglicisms, which are common in Internet environments, being the focus of modern Internet communication through borrowed vocabulary as a sign of dedication and exclusivity. At the same time, we reasonably offer specific Ukrainian equivalents as the actualization of possibilities of the native language and advantages of the national linguistic usage, as reflected in one of the tables (Table 2).

Anglicisms and pseudoanglicisms are grouped by areas of Internet communication, which sometimes have too fine a line between them, considering the inevitable

Table 3 Root words of anglicisms and pseudoanglicisms

Internet communication area	Examples of anglicisms
Proto-Germanic	Ball, board, book, brand, build, come, craft, dead, doodle, draft, foot, free, hack, harass, hard, hate, head, hold, home, lap, life, list, lock, long, look, name, road, shop, shore, short, show, sight, skill, soft, speak, stake, start, stick, team, tease, tell, top, trend, troll, watch, web, word, work
Latin	Abuse, affiliate, bill, case, cash, chain, challenge, check, content, cross, digest, event, explain, facilitate, fact, fiction, gender, horror, influence, lance, line, media, message, mix, mob, monitor, picture, press, pride, puzzle, quest, scout, sex, site, spoil, sport, story, train, tutor, video
Other	Biography (грец.), bot (старослов.), coach (угор.), hype (грец.), meme (грец.), mentor (грец.), school (грец.)
Unknown	Bird, bully, cast, fake, fit, freak, fuck, gay, goal, hub, kit, log, pitch, traffic
Echoism (onomatopoeia)	Boost, chat, flash

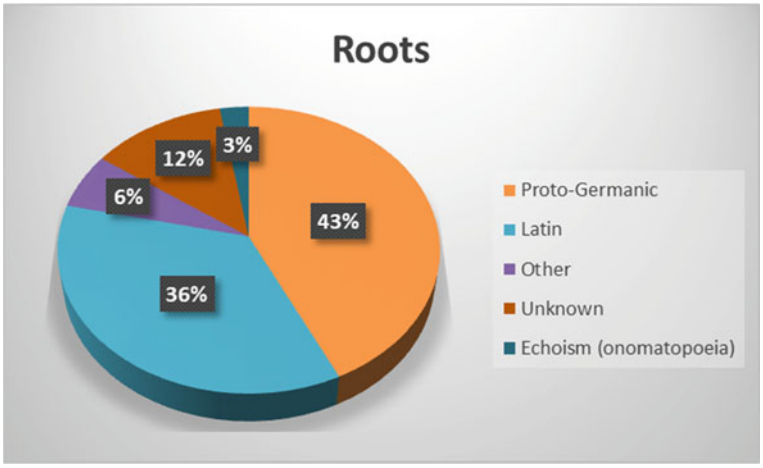

Fig. 12 Classification of anglicisms and pseudoanglicisms based on the root word

flowing of various types of social activity: educational (булінг – цькування), cultural (байопик – біографічний фільм), economic (офшор – безподаткова зона), media (дайджест – огляд), network (онлайн – в мережі), everyday (дедлайн – реченець), sociopolitical (спікер – речник) (Table 1).

As a result of the analysis of lexico-semantic expansion of anglicisms, their division has been offered into three main grous (Fig. 1): barbarization, expanded borrowing, reasonable borrowing, among which the largest group is barbarization—borrowing with existing and unclaimed equivalent in translation dictionaries, as well as the specific equivalent proposed in our study (67%). Expanded borrowings as

an opportunity to replenish the synonymic row through synonymic shades in the meaning and nomination of a new term in the absorbing language is 14%, hence, reasonable borrowings as the author's innovations in the English language (and at the same time, a new reality in the absorbing language) are identified with 19% personomy, while among all analyzed anglicisms, personomen are 22% (Fig. 2). This indicates the extraordinary creativity and ingenuity of the English-speaking world.

Internet information and socio-cultural context has been traced through the prism of significant anglicisms (or pseudoanglicisms) by three main groups of lexico-semantic expansion (Tables 1 and 2): чат and pseudoanglicism квест with derivatives веб-квест, квест-перформенс (barbarization); троль, тролінг—expanded borrowings as an opportunity to replenish the synonymic row through the conceptual absence in source language and synonymic shades in meaning; блог and its derivatives—as the author's borrowed innovation. Paradigmatic-syntagmatic connections of these words and Ukrainian equivalents to them as the way the Internet environment communicates [71, 72] with the help of specific vocabulary as reflected in different charts (Figs. 5, 6, 7, 8 and 9).

Etymological analysis of anglicisms made it possible to identify and distinguish a separate group of pseudoanglicisms with a predominantly Latin stems making 37% (Fig. 3, Table No.) and anglicisms with Proto-Germanic etymology 45%.

The main idea of this study and its future perspective is a systematic lexico-semantic and etymological analysis of new anglicisms (and Americanisms) as actualisators of cogitativity in the Ukrainian language that has all the possibilities to use, rethink and create specific lexical units in the Internet communication.

References

1. Crystal, D.: English as Global Language. Moscow (2001)
2. Muromtseva, O.: Development of the Ukrainian Literary Language the 2nd Half. XIX—Post. XX Art. Kharkiv (1985)
3. Goldovansky, Y.: The development stages of words with foreign origin in the lexical system of the recipient language. Foreign Philol. **69**, 17–21 (1983)
4. Goldovansky, Y.: Lexical Anglicisms in Modern Ukrainian Language. Ukrainian Vocabulary in Its Connections with Neighbor Slavic and Non-Slavic Languages. Uzhgorod (1982)
5. Goldovansky, Y.: Dictionary of Anglicisms (2018). https://kzref.org/slovnik-anglicizmiv.html
6. Oleksienko, S.: On lexico-semantic development of loanwords. Movoznavstvo **3**, 14–17 (1976)
7. Popova, N.: English borrowings in the lexico-semantic system of the Ukrainian language from the end of the XXth century to the beginning of the XXIst century. Thesis' abstract, Kharkiv (2002)
8. Stishov, O.: Dynamic processes in the lexical-semantic system and word formation of the Ukrainian language of the end of twentieth century (based on the mass media's materials). Doctoral thesis, Kyiv (2003)
9. Fedorets, S.: English loanwords in the language of modern Ukrainian advertising. Thesis, Kharkiv (2005)
10. Arkhipenko, L.: Foreign lexical borrowings in the Ukrainian language: stages and degrees of adaptation (based on the material of English presence in the press of the late XX–early XXI century). Thesis, Kharkiv (2005)

11. Bytkivska, J.: Tendencies of anglicisms' adoption and semantic development in modern Ukrainian language. Thesis, Ternopil (2008)
12. Lapinska, O.: Anglicisms in the structure of the Ukrainian literary text of the late XX–early XXI centuries. Thesis' abstract, Dnipropetrovsk (2013)
13. Maistruk, T.: English borrowings in functional and stylistic varieties in the Ukrainian language of the late XX–early XXI centuries. Thesis' abstract, Kryvyi Rih (2010)
14. Yasynetska, N.: Structural-semantic features and functioning of nowadays anglicisms in the Ukrainian language. Thesis, Kyiv (2013)
15. Mańczak-Wohlfeld, E., Witalisz, A.: Anglicisms in The National Corpus of Polish: assets and limitations of corpus tools. Stud. Pol. Linguist. **14**(4), 171–190 (2019)
16. Witalisz, A.: Polish LGBTQ+-related anglicisms in a language contact perspective. Studia Anglica Posnaniensia **56**(1), 631–653 (2021)
17. Zabawa, M.: O coming oucie i wyrażeniach pokrewnych w polszczyźnie. LingVaria Rok XVI **2**(32), 107–118 (2021)
18. Bozděchová, I., Klégr, A.: Pseudoanglicisms: Czech neologisms based on English words. Slovo a Slovesnost **83**(1), 3–27 (2022)
19. Chlebowski, M.: An glicyzmy leksykalne i ich derywaty w języku czeskim na podstawie gazety „Mladá fronta Dnes". Bohemistyka **4**, 484–500 (2019)
20. Entlová, G.: Novotvary a interncionalismy v češtině v období pandemie covid-19. Bohemistyka **1**, 20–34 (2022)
21. Entlova, G., Mala, E.: The occurrence of anglicisms in the Czech and Slovak lexicons. XLinguae **13**(2), 140–148 (2020)
22. Panocová, R.: Attitudes towards anglicisms in contemporary standard Slovak. Int. J. Lexicogr. **33**(2), 187–202 (2020)
23. Morić-Mohorovičić, B.: Jezični trendovi hrvatskih modnih portata. Slavisticna Revija **69**(2), 183–194 (2021)
24. Klajn, I.: Neologisms in present-day Serbian. Int. J. Sociol. Lang. **151**, 89–110 (2021)
25. Niklas-Salminen, A.: Les recommandations officielles proposées pour remplacer les anglicismes dans le «Petit Robert de la langue française». Kalbotyra **74**, 141–159 (2021)
26. Walsh, O.: «Les anglicismes polluent la langue française». Purist attitudes in France and Quebec. French Lang. Stud. **24**, 423–449 (2014)
27. Duběda, T.: The phonology of anglicisms in French, German and Czech: a contrastive approach. J. Lang. Contact **13**, 327–350 (2020)
28. Brecelj, K.K.: Uno sguardo ad alcuni anglicismi nella lingua italiana durante il periodo Covid-19. Vesnik za tuje jezike. J. Foreign Lang. 147–163 (2020)
29. Gazzardi, A., Vásquez, C.: A taxonomic approach to the use of English in the Italian media. World Engl. **41**(2), 271–284 (2022)
30. Pulcini, V.: Internationalisms, Anglo-Latinisms and other kinship ties between Italian and English. Studia Linguistica Universitatis Iagellonicae Cracoviensis **136**, 121–141 (2019)
31. Deeney, I., Beletskaya, O.: English borrowings in the Spanish language: language policy of the Royal Academy of the Spanish language and the Fundéu BBVA regarding anglicisms. Research Result. Theor. Appl. Linguist. **7**(2), 13–20 (2021)
32. Luján-García, C.: Anglicisms in the area of food and drinks among Spanish speakers. Why are anglicisms used to refer to food and drinks related terms in Spanish? Analele Universitatii din Craiova - Seria Stiinte Filologice, Lingvistica **43**(1–2), 180–190 (2021)
33. Farion, I.: Anglo-barbarization: Term and Reality. Terminological Actualization of the Ukrainian Linguistic Reality, pp. 5–39. Lviv (2020)
34. Gorot, E., Kotsyuk, L., Malimon, L., Pavlyuk, A.: English-Ukrainian Dictionary. Vinnytsia (2006)
35. Chat. https://www.dictionary.com/browse/chat
36. Chat. https://www.lexico.com/en/definition/chat
37. Online Etymology Dictionary (2001). https://www.etymonline.com/
38. Dictionary of the Ukrainian Language: In 11 Volumes. Kyiv (1970–1980)

39. Zeitlini, R. (ed.): Old Slavonic Dictionary (According to Manuscripts of the X–XI Centuries). Moscow (1999)
40. Etymological Dictionary of the Ukrainian Language, pp. 1–6. Kyiv (1982–2012)
41. Dictionary of the Old Ukrainian Language of the XIV–XV Centuries, pp. 1–2. Kyiv (1977–1978)
42. Tymchenko, E.: Materials for the Dictionary of Written and Bookish Ukrainian Language of the XV–XVIII Centuries, pp. 1–2. Kyiv, New York (2003)
43. Dictionary of the Ukrainian Language of the 16th–First Half of the 17th Century: in 28 Issues. Issues 1–14. Lviv (1994–2008)
44. Vusyk, O.: Dictionary of Synonyms of the Ukrainian Language. Ternopil (2013)
45. Quest as a Form of Homeschooling. https://nus.org.ua/articles/kvest-yak-forma-navchannya-vdoma/
46. Dictionary of Foreign Words. Kyiv (2000)
47. Osipov, P.: Latin Phraseology: Handbook Dictionary. Kyiv (2009)
48. Quest. https://slovotvir.org.ua/words/kvest
49. Zhitetsky, P.: Selected Works. Philology. Kyiv (1987)
50. Trolling. https://en.wikipedia.org/wiki
51. Trolinh. https://slovotvir.org.ua/words/trolingh
52. ARS—English-Russian Dictionary. Moscow (1981)
53. CD—Cambridge Dictionary. https://dictionary.cambridge.org
54. Trolling. https://www.dictionary.com/browse/trolling
55. Troll. https://en.wikipedia.org/wiki/Троль
56. Voitovych, V.: Ukrainian Mythology. Kyiv (2002)
57. Kononenko, O.: Ukrainian Mythology and Cultural Heritage. Kharkiv (2011)
58. Blog. General People's English-Ukrainian Dictionary (2010). https://e2u.org.ua/s?w=blog&dicts=all&highlight=on&filter_lines=on
59. Blog. https://www.lexico.com/en/definition/blog
60. Sangameswar, M., Rao, M., Kumar, S.: Building a natural disaster management system based on blogging platforms. Int. J. Mod. Educ. Comput. Sci. (IJMECS) **9**(8), 32–39 (2017). https://doi.org/10.5815/ijmecs.2017.08.05
61. Hanxiang, W., Mingjun, X., Weimin, L., Zhihua, N.: An approach to micro-blog sentiment intensity computing based on public opinion corpus. Int. J. Wirel. Microw. Technol. (IJWMT) **2**(5), 53–61 (2012). https://www.mecs-press.org/ijwmt/ijwmt-v2-n5/v2n5-8.html
62. Mingjun, X., Hanxiang, W., Weimin, L., Zhihua, N.: A public opinion classification algorithm based on micro-blog text sentiment intensity: design and implementation. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **3**(3), 48–54 (2011). https://www.mecs-press.org/ijcnis/ijcnis-v3-n3/v3n3-7.html
63. Online Etymology Dictionary. http://www.etymonline.com/index.php?term=blog
64. Barger. Material from Wikipedia. https://360wiki.ru/wiki/Jorn_Barger
65. How Jorn Barger Invented Blogging. https://techblog.sdstudio.top/kak-jorn-barger-izobrel-blogging/
66. Andrusyak, I.: Blog terms as a part of the English-speaking blogosphere. Modern research in foreign philology. Collection of scientific works. Issue 14, pp. 15–23. Uzhhorod (2016)
67. Blog. Wikipedia: The Free Encyclopedia. https://en.wikipedia.org/wiki/Blog
68. Graham, B.: Must See HTTP: The BradLands. http://www.bradlands.com/weblog/comments/september_10_1999/
69. Quick, W.: Daily Pundit: Internet Archive WAYBACKMACHINE. http://www.iw3p.com/DailyPundit/2001_12_30_dailypundit_archive.html
70. Blogging as a phenomenon of modern information society. https://op.edu.ua/sites/default/files/publicFiles/studolympconf/fenomen_blogerstva.pdf
71. Ayeni, O.A., Mercy, A., Thompson, A., Mogaji, A.: Web-based student opinion mining system using sentiment analysis. Int. J. Inf. Eng. Electron. Bus. (IJIEEB) **12**(5), 33–46 (2020). https://doi.org/10.5815/ijieeb.2020.05.04

72. Saha, S., Kumar, K.: Emoji prediction using emerging machine learning classifiers for text-based communication. Int. J. Math. Sci. Comput. (IJMSC) **8**(1), 37–43 (2022). https://doi.org/10.5815/ijmsc.2022.01.04

Dynamic and Distributed Service Discovery Based Management System for City Parking Statistics Data Collection from Mobile Scanner Vehicles

Olena Shlyakhetko, Jakub Cybulski, Stanisław Biały, and Piotr Szymczak

Abstract This paper analyzes how developers can approach incorporating components based on service discovery technology to create a decentralized orchestration system connecting multiple remote services and allowing them to perform independent actions like continuous data sharing with other registered independent parties. To showcase these capabilities and usage of this model, example scenario is presented with a component for collecting and transmitting data originating from multiple mobile vehicles as well as monitoring application capable of connecting with any number of aforementioned working services operating within mentioned vehicles. To combine and configure data flow between both modules, the last part of the system contains the implementation of supplemented service discovery components utilized especially for that approach. Results show the effectiveness of the adaptation of predefined technologies and components in the production of a dynamic decentralized data sharing system as well as along with the simplicity in configuring specified modules to interact asynchronously with each other. From the marketing perspective, this study emphasizes how to create a modern system with advanced communication protocols due to provided high-class components without in-depth knowledge which can be utilized as commercial easily expandable application.

Keywords Distributed service · Statistics data · City parking · Management system · Mobile scanner vehicles · Service · Discovery service

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1 Introduction

Nowadays one can notice trend where ever growing number of services and systems adopt decentralized architectures [1] striving to be modular where each module is capable of performing independent actions at the same time. Such components which as a whole create interconnected ecosystem [2] allow for great versatility when it comes to scalability and fault proofing devised process.

Flexibility and minimum user intervention [3] are essential for such networks which are to be easily deployed and reconfigured automatically [4] when extended with new hardware or software capabilities [5].

Embracing this approach on the other hand poses challenges with orchestration and discoverability of nodes hosting the components.

For instance given mobile application [6–10], where by mobile it is meant that the application moves relatively to the network [11–15], i.e. it is changing IP address [16, 17], there's a need to track these changes to make the application remotely reachable from the outside considering overall system process.

Service discovery mechanism [18], which allows devices to automatically discover network services with their attributes and advertise their own capabilities to the rest [19] of the network, is a major mechanism for such self-configurable networks [20].

There are already several solutions for tackling the matter utilized by big profile companies [21]. An example of that is Eureka resource discovery system [22] which provides the ability to programmatically discover components that provide or depend on specific resources, such as libraries or component services.

The other technology solving given issue is Azure IoT Hub [23, 24] which focuses on security in context of big scale production deployments. In this paper we will exercise service discovery management system where there is variable number of active services representing cars [25] cruising through some area collecting data about parked vehicles.

The presented challenge is to keep track of their network [26, 27] so they can be easily discovered by the process aggregating the data from all dependent nodes which will announce their presence.

In traditional approach (Fig. 1) with static preconfigured data there is no option to change once deployed status of service mapping [28]. The only option to change it is by uploading new configuration file into database.

Such pattern might cause introduction of obsolete information about the services [29–31], additionally access information to newly deployed [32] instances might be delayed.

With the new innovational proposed dynamic approach (Fig. 2) each service will connect directly into remote dynamic service discovery provider [32] for registration. It will allow seamlessly integrating new deployments as well as persisting current data [33] about working vehicles.

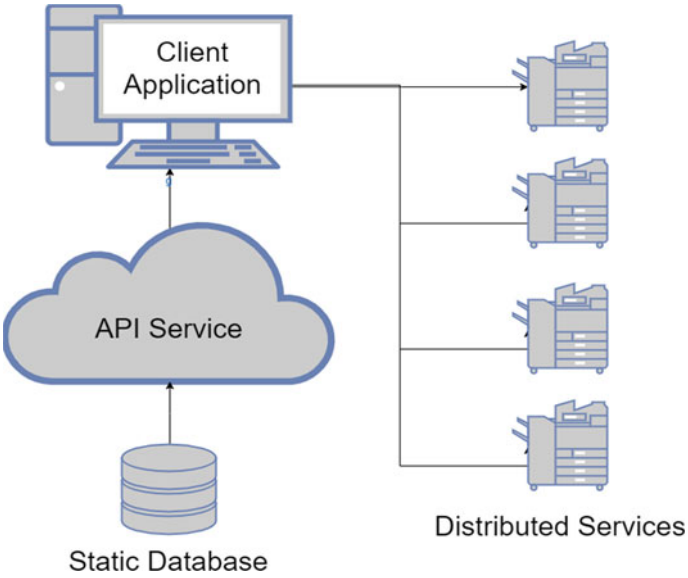

Fig. 1 Classical static approach

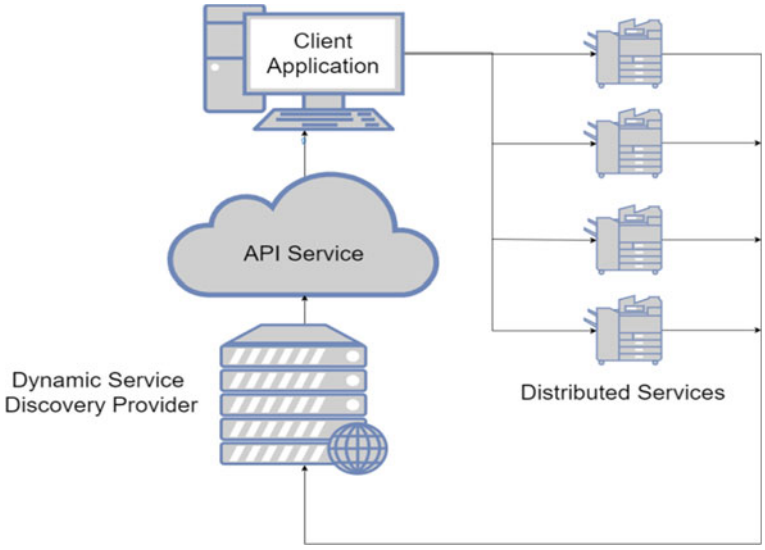

Fig. 2 Proposed dynamic approach

2 Problem Statement

Consider a huge city where cars check the parking density [34–37]. At some point, by enlarging the city's borders, it was found to extend the parking zones [38, 39]. To control the fees of the new car parks will be purchased an additional 1000 cars or any other number. We need to add new cars to the service in a short period of time [40].

We can do it manually by entering car addresses and logging in data. The problem is a large quantity of data manually completed, and when changes occur we need to change it again. Human mistake in e.g. configuration [5] can cause errors in the connection.

We do not know what will happen to the connection with the car at the moment of changing the address, crash or disconnection? Given one thousand cars have been purchased, and the known address of the Service Discovery system [4] has been provided together with configuration for each car. At the moment of launching, the cars are prompting inquiries with their information to the Service Discovery server.

Data is sent to the system not only from cars, but also from other network components [41]. At this point, the Service Discovery system [40] becomes a server with information about all available services, cars and components.

Their location, capabilities, status and what they do. At this point, when calling the API [3] with information about available cars, we do not use the database with information about cars, and we get information from Service Discovery with the most recent information [40, 41].

3 Component Roles

On the below graph (Fig. 3) the overall flow of the process is presented.

3.1 Vehicle Mounted System

This component's purpose is to gather the most essential pieces of data that will enable the whole system to function.

Gathered information incorporates imagery data [34] used to estimate density of parked vehicles.

Following data will be sent upon request to client [42]. Each instance of that system will perform registration allowing server discovery to track their status (Fig. 4).

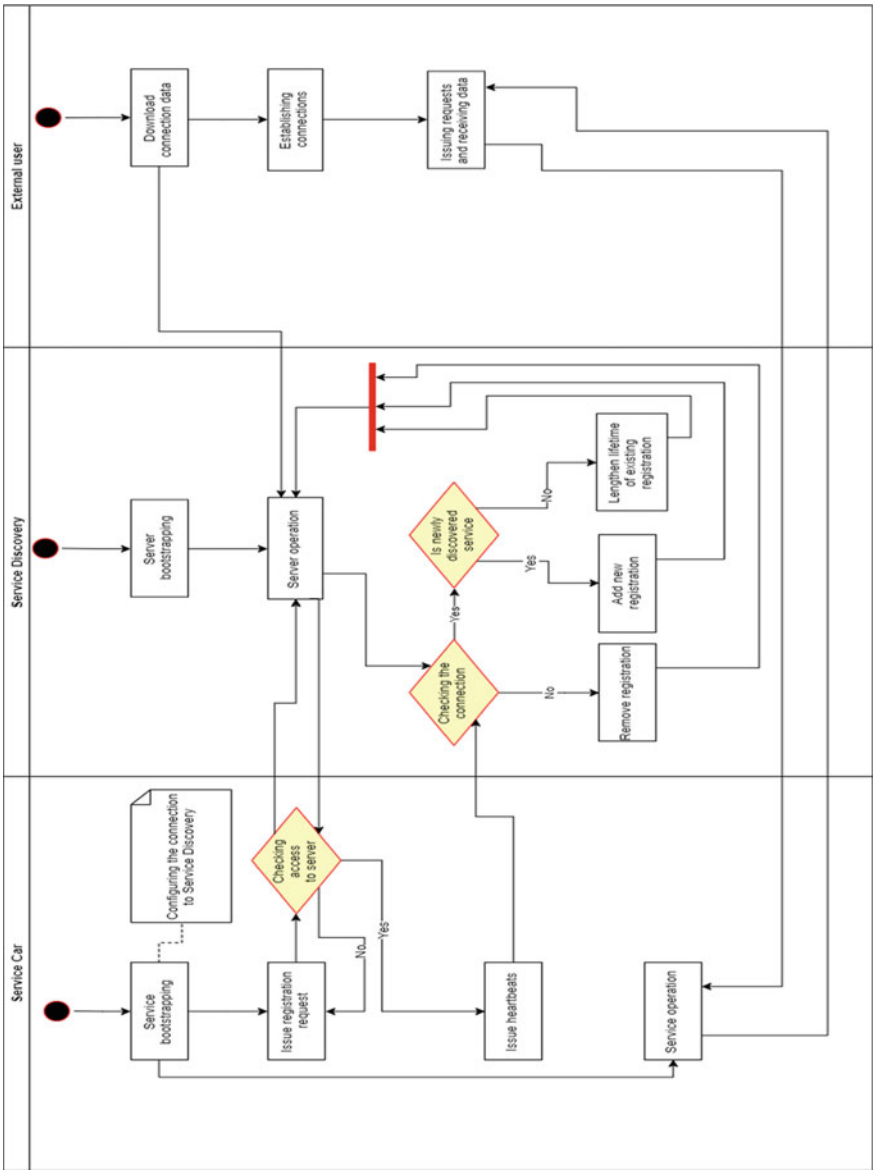

Fig. 3 Overall process graph

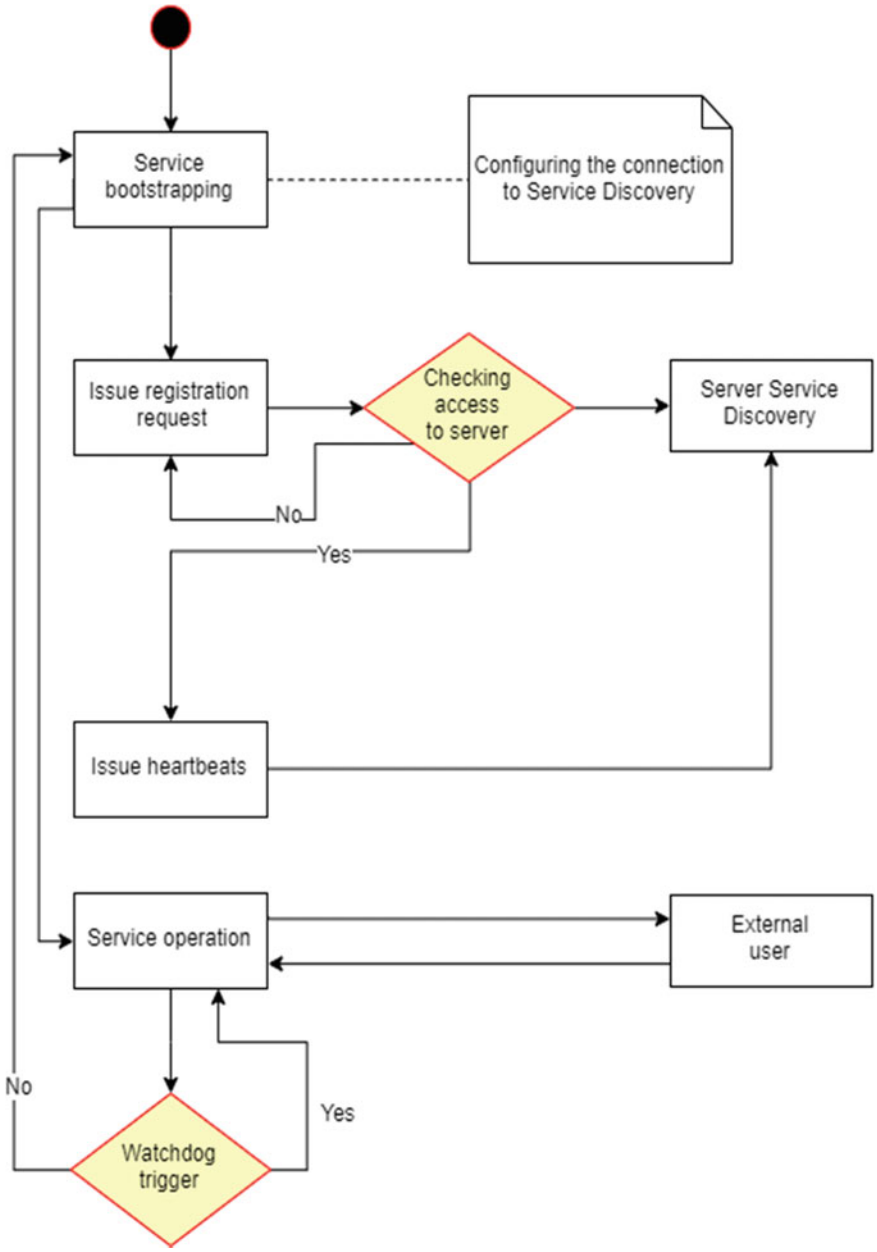

Fig. 4 Vehicle process graph

3.2 Service Discovery System

This module traces status of remote services by awaiting registration request from remote parties thus obtaining connection parameters [5] which in turn will allow direct connection with the service. Its other responsibility is to monitor the health of established registrations by tracking [3] incoming heartbeat requests (Fig. 5).

3.3 Service

This service enables withdrawing data from Data discovery service about currently registered vehicles like their status and functionalities [42].

3.4 Client Application

Client application presents information aggregated from currently registered services and provide user with information [28] and it operates according to the following graph (Fig. 6).

4 Implementation

For implementation purposes we are proposing a sandboxed [43] environment in which the simulation of the recognition process will be performed.

For this purpose, there are following components:

4.1 Server Application

Written using .Net Core [44] technology utilizing ASP web framework [44]. The RESTful Api [45] provides clients means of obtaining necessary data such as list of connected remote vehicles. As well as authentication and authorization procedures based on JWT (JSON Web Tokens [46]).

Within of itself it also hosts Eureka server [22] listening for registrations and maintaining obtained lifetime handles of aforementioned registrations.

The server is designed to be a long lived singleton element of the system.

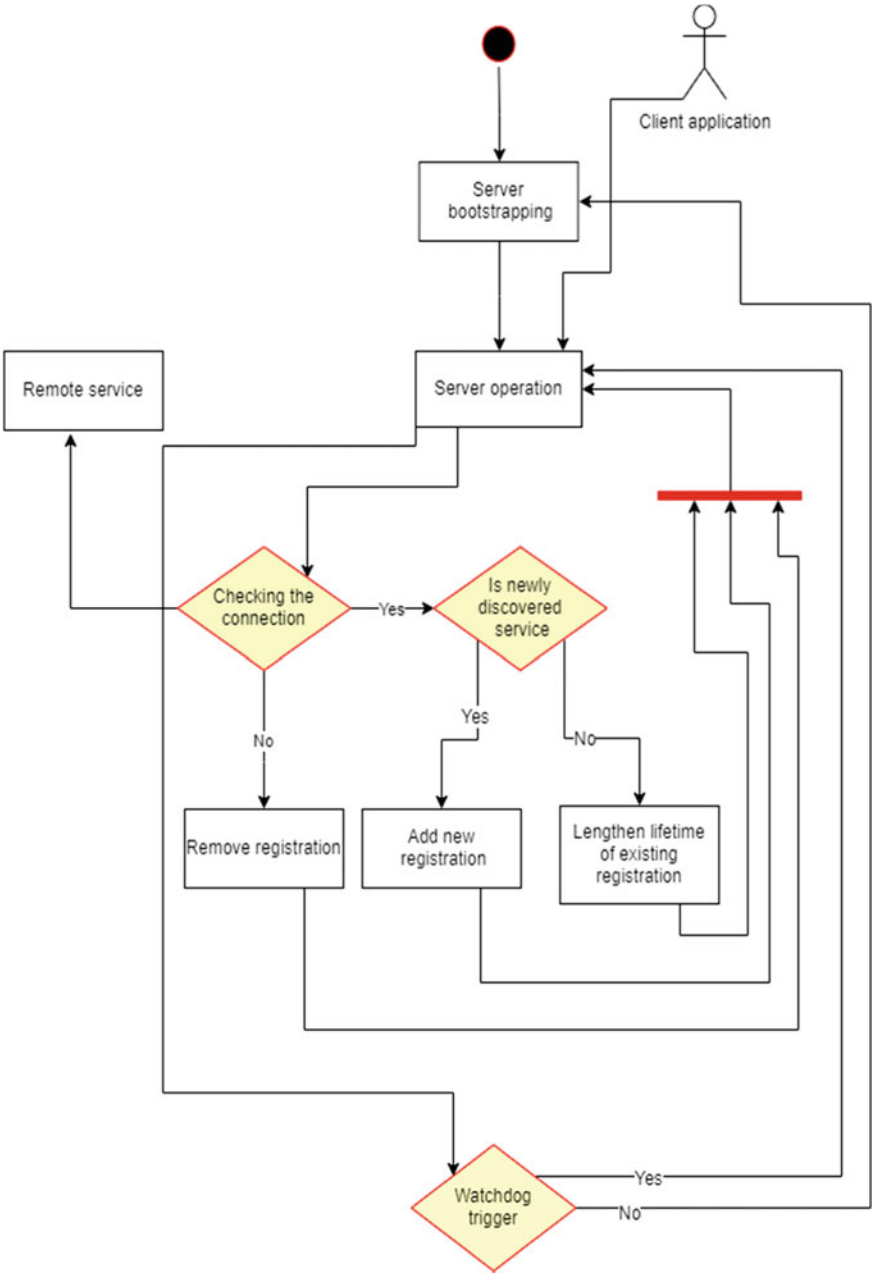

Fig. 5 Discovery system process graph

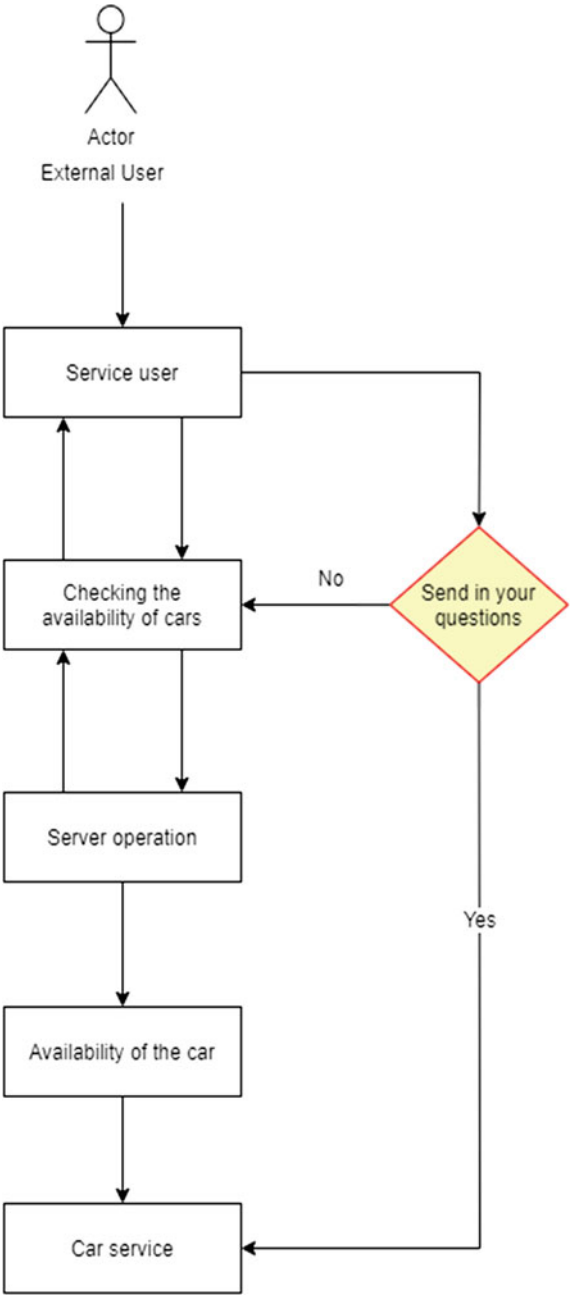

Fig. 6 Client application process graph

4.2 Client Application

For proof of concept scenario, it is assumed it's simply a monitoring application implemented using UWP (Universal Windows Platform) technology. It is initiating system authorization flow and upon successful authentication it retrieves information about means of accessing the remote data sources [47].

Having that done it proceeds to establish connections with remote services, given that data is being made available in asynchronous manner [48] there's a need to establish subscription to given resource.

For this purpose, the client will create number of GraphQL [49] WebSocket [19] based tunnels used for forwarding data.

The data then will be presented on the interface:

- Geolocation data—presented on the interactive map
- Parking density data
- Scanned registration plates.

The application presents scanning sessions from multiple vehicles (Fig. 7) which info is obtained from the service discovery system. Upon connection the list of single recognitions is presented as well as a picture of scanned vehicle (mocked with grey placeholder rectangle) (Fig. 8).

The map is presenting where the vehicles have been scanned.

4.3 Mobile Distributed Service

These services are the actual working entities of the system, same as the server component they are implemented using .Net Core [44] technology with ASP web server running which will be queried by the client application [5].

Instead of hosting Eureka server [22] it will be issuing registration requests to the server application and issuing required heartbeats ensuring steady access to the service. Furthermore, it is required for it to generate ALPR data stream containing information on the virtually parked vehicles as well as mocked GPS [50] data position (Fig. 9).

Finally, GraphQL Api [49] is exposing live information in the form of versatile subscriptions based on WebSockets [51].

The client application allows the operator to monitor current system state as well as various additional data and interact with the system. The main operator screen (Fig. 11) shows current position on a map as well as scanned registration plates, enables the user to enable or disable scanning as well choose which side of the road to scan.

The statistics page gives a quick glance of the parking data (Fig. 10) such as vehicle country distribution. It is also possible to define and browse parking zones to which scanning will be limited.

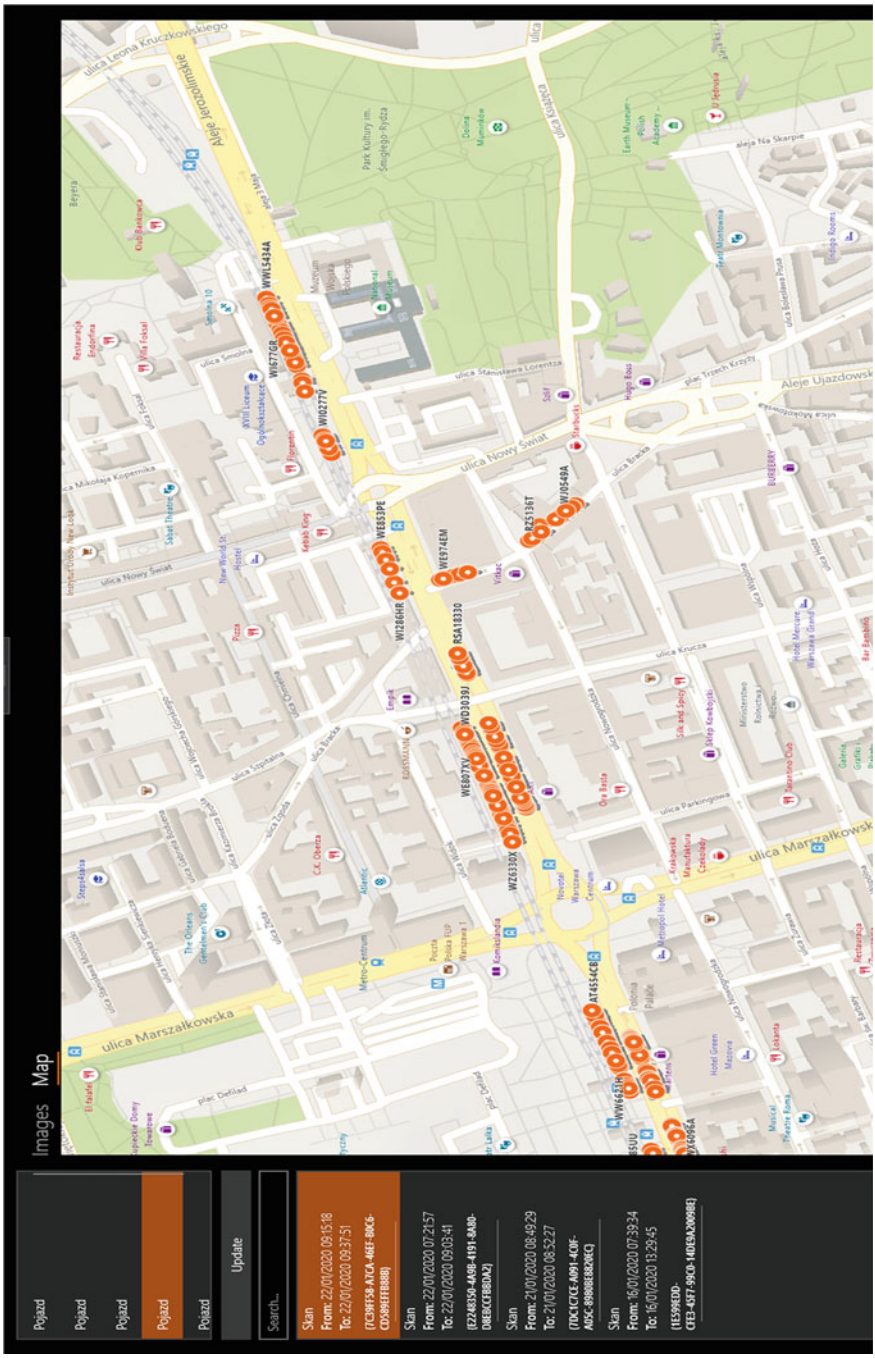

Fig. 7 Parking density with geolocation data (mocked)

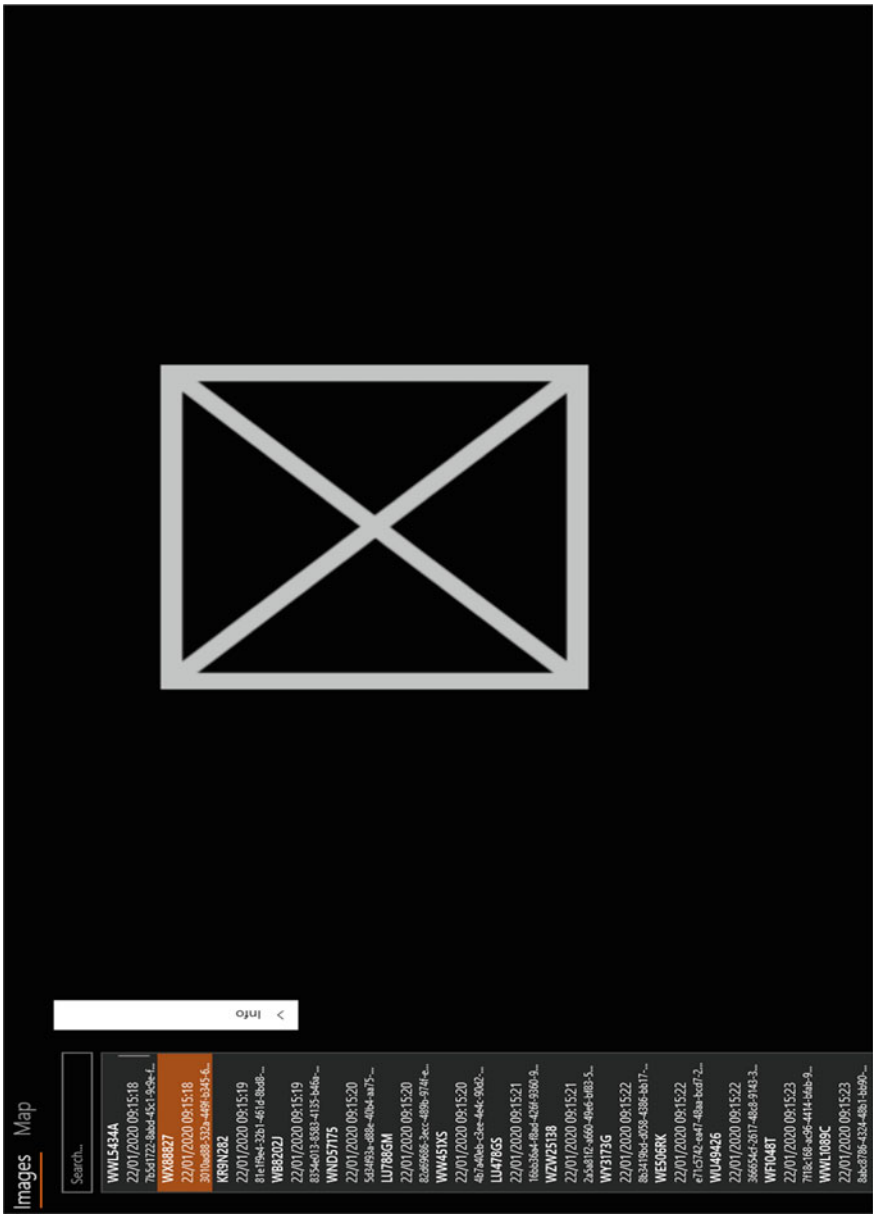

Fig. 8 Scan browser with imagery data (mocked)

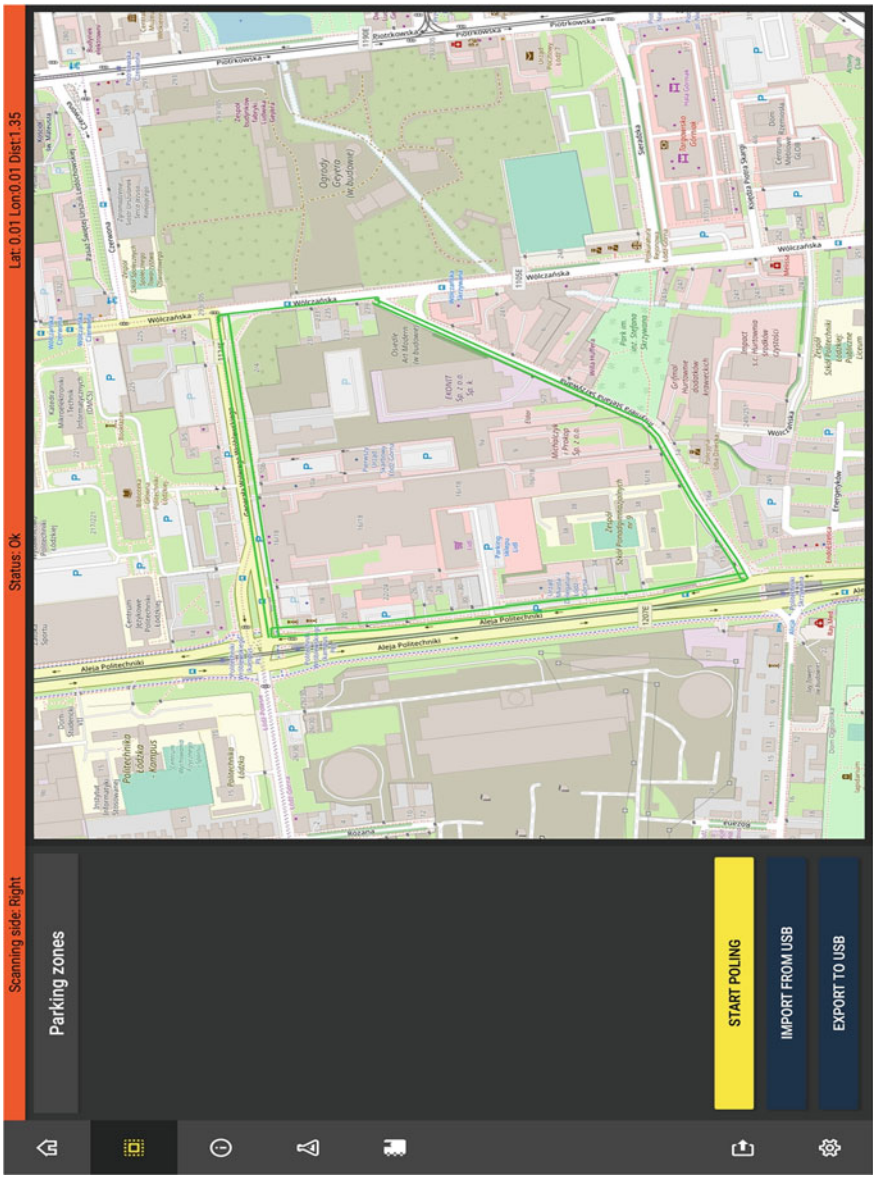

Fig. 9 Vehicle operator application

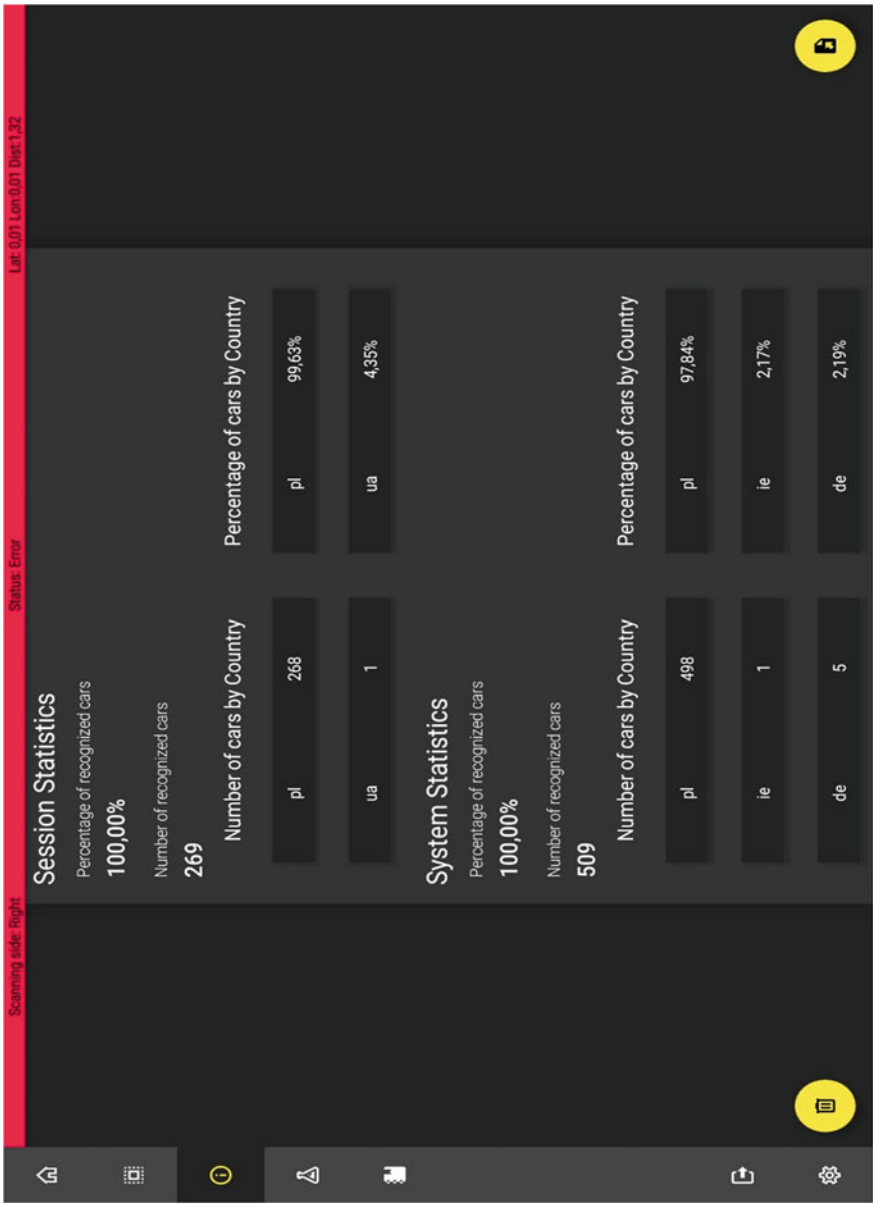

Fig. 10 Parking data statistics

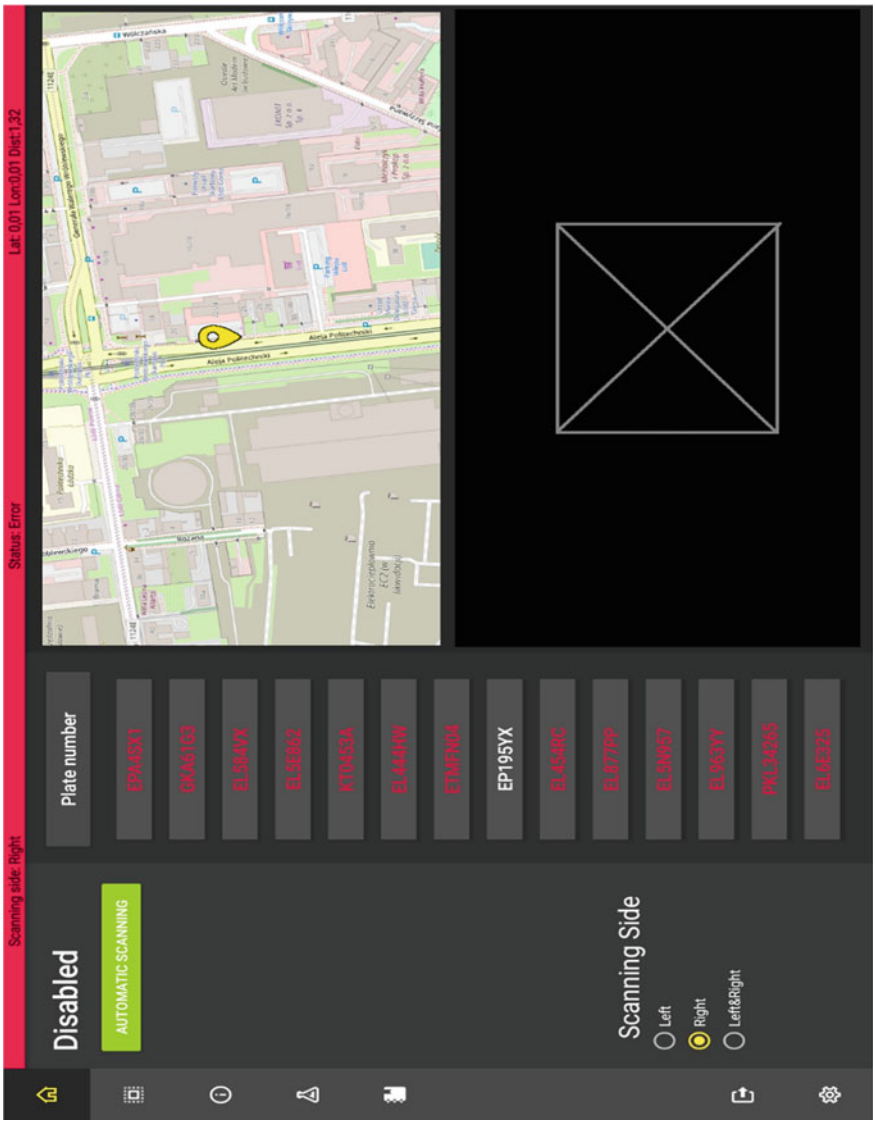

Fig. 11 Main operator screen

4.4 Technologies Breakdown

Here we will briefly discuss technologies that are used to achieve the goal of this work.

.Net Core.

- It is an application runtime providing a rich base class library on top of fully portable cross-platform environment providing managed way of software development [44]. Enables us to implement all software services required for the system to function.

ASP Core.

- It is a web framework which is devised for .Net Core, it's versatile enough to host a variety of plugins which enable it to perform much more actions than just exposing REST Api [44, 45]. Thanks to it we have achieved effective communication between actual nodes.

Eureka.

- It is a solution brought my Netflix to solve the problem of finding and orchestrating access to microservices deployed in a distributed fashion [42]. Provides the main concept exercised in this paper i.e. service discovery.

GraphQL.

- It is an alternative approach for creating Web based APIs like REST. It offers strongly typed requests which can be composed by the client according to the Schema defined by the server. Furthermore, it provides Websocket subscription protocol enabling easy asynchrony [49, 51].

Xamarin.Android.

- Is a framework designed to enable.Net applications running on Android devices, using a single language stack we achieve great consistency with the codebase. Used to create a mobile tablet application which is on board every scanner vehicle.

5 Model Testing

It's challenging to properly test given model. Due to immense number of variables and real-world data like imagery for ALPR systems or GPS data for localization.

In order to test and validate proposed model we are exercising scenario with assumptions that ALPR and other positioning system are working correctly and we are focusing on the vehicle connectivity and registrations.

There are various challenges regarding both hardware and software elements. The only viable solution to cloud-enable the car is to use cellular data, for example LTE connection, which requires SIM card and proper modem device capable of providing stable connectivity.

The other important factor is security, with potentially sensitive data being transmitted proper measure have to be taken, VPN connection may be required.

The bandwidth used by the device calls for data batching or different synchronization techniques like for example Wi-Fi connection when cars return to the base of operations after day of work.

6 Conclusions

Thanks to the adoption of the dynamic discovery system it was possible to achieve seamless integration of number of vehicles cruising through the city gathering data, it is easy to register additional instances with close tono hassle. Utilizing Publisher-Subscriber communication model enables efficient gathering of asynchronous data from various sources. Though in-depth validation of the proposed solution requires much more work due to the topic being complex and touching a number of fields like Machine Learning, Networking, GPS positioning and much more. That being said, focusing on the dynamic service discovery aspect it appears that it is a valid approach which should yield positive results at the end of the day.

References

1. Mutambara, A.G.O.: Decentralized estimation and control for multisensor systems. Routledge (2019)
2. Adhikari, K., Hartemink, A.E.: Linking soils to ecosystem services—a global review. Geoderma **262**, 101–111 (2016). https://doi.org/10.1016/j.geoderma.2015.08.009
3. Chapiewski G.deB, Quintana M., Kumar M., Lettau T., Patterson W. (2018) User intervention based on tracking device location. US10002515B2
4. Guttman, E.: Service location protocol: automatic discovery of IP network services. IEEE Internet Comput. **3**(4), 71–80 (1999). https://doi.org/10.1109/4236.780963
5. Kozat, U.C., Tassiulas, L.: Network layer support for service discovery in mobile ad hoc networks. In: IEEE INFOCOM 2003. Twenty-second annual joint conference of the IEEE computer and communications societies (IEEE Cat. No. 03CH37428), 2003, vol. 3, pp. 1965–1975 vol.3, doi: https://doi.org/10.1109/INFCOM.2003.1209218.
6. Koneru R.K. et al.: (2016) Mobile application management systems and methods thereof. US9405723B2
7. Priya, R., Gavaskar, S.: A novel method of corporation water distribution to smart city with IoT devises based on survey. Lect. Notes Netw. Syst. **401**, 375–387 (2023). https://doi.org/10.1007/978-981-19-0098-3_37
8. Fomy, K.F., Mahmud, A., Islam, M., Rahim, S.: Road rush: a review on road traffic analytics systems and a proposed alternative. Int. J. Inf. Technol. Comput. Sci. (IJITCS) **14**(2), 54–63 (2022). https://doi.org/10.5815/ijitcs.2022.02.05
9. Iamtrakul, P., Klaylee, J.: Creating a prototype smart city for a case of developing world: Pathum Thani, Thailand. GMSARN Int. J. **17**(1), 67–75 (2023)
10. Singh, S.K., Pan, Y., Park, J.H.: Blockchain-enabled secure framework for energy-efficient smart parking in sustainable city environment. Sustain. Cities Soc. **76** (2022). https://doi.org/10.1016/j.scs.2021.103364
11. Fataliyev, T.K., Mehdiyev, S.A.: Integration of cyber-physical systems in e-science environment: state-of-the-art, problems and effective solutions. Int. J. Mod. Educ. Comput. Sci. (IJMECS) **11**(9), 35–43 (2019). https://doi.org/10.5815/ijmecs.2019.09.04
12. Hu, Z., Odarchenko, R., Gnatyuk, S., Zaliskyi, M., Chaplits, A., Bondar, S., Borovik, V.: Statistical techniques for detecting cyberattacks on computer networks based on an analysis of abnormal traffic behavior. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **12**(6), 1–13 (2020). https://doi.org/10.5815/ijcnis.2020.06.01
13. Koumetio Tekouabou, S.C., Abdellaoui Alaoui, E.A., Cherif, W., Silkan, H.: Improving parking availability prediction in smart cities with IoT and ensemble-based model. J. King Saud Univ.-Comput. Inf. Sci. **34**(3), 687–697 (2022). https://doi.org/10.1016/j.jksuci.2020.01.008

14. Faraji, P.H., et al.: Deep learning based street parking sign detection and classification for smart cities 254–258 (2021). https://doi.org/10.1145/3462203.3475922
15. Hilal, H.A., Hilal, N.A., Hilal, A.A., Hilal, T.A.: Crowdsensing application on coalition game using GPS and IoT parking in smart cities. **201**(C), 535–542 (2022). https://doi.org/10.1016/j.procs.2022.03.069
16. Wang, S., Zhang, L., Tang, C.: Ethernet address resolution in the context of dynamic IP address changes. IEEE Int. Conf. Online Anal. Comput. Sci. (ICOACS) **2016**, 306–309 (2016). https://doi.org/10.1109/ICOACS.2016.7563103
17. Hu, Z., Dychka, I., Onai, M., Yu, Z.: Blind payment protocol for payment channel networks. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **11**(6), 22–28 (2019). https://doi.org/10.5815/ijcnis.2019.06.03
18. Bhandari, S.S., Thubert, P., Mani, S.: Service discovery optimization in a network based on bloom filter. US10277686B2 (2019)
19. Hasibuan, A., Mustadi, M., Syamsuddin, Ir.E.Y., Rosidi, Ir.M.A.: Design and implementation of modular home automation based on wireless network, REST API, and WebSocket. In: 2015 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS), pp. 362–367 (2015). https://doi.org/10.1109/ISPACS.2015.7432797
20. Service Discovery in Pervasive Computing Environments (2005). https://www.computer.org/csdl/magazine/pc/2005/04/b4081/13rRUxC0SBm. Accessed 21 Nov. 2019
21. Jamshidi, P., Pahl, C., Mendonça, N.C., Lewis, J., Tilkov, S.: Microservices: the journey so far and challenges ahead. IEEE Softw. **35**(3), 24–35 (2018). https://doi.org/10.1109/MS.2018.2141039
22. Pauls, K., Hall, R.S.: Eureka—a resource discovery service for component deployment. In: Component Deployment, Berlin, Heidelberg, pp. 159–174 (2004). https://doi.org/10.1007/978-3-540-24848-4_11
23. Ammar, M., Russello, G., Crispo, B.: Internet of things: a survey on the security of IoT frameworks. J. Inf. Secur. Appl. **38**, 8–27 (2018). https://doi.org/10.1016/j.jisa.2017.11.002
24. Tekouabou, S.C.K., Alaoui, E.A.A., Cherif, W., Silkan, H.: Improving parking availability prediction in smart cities with IoT and ensemble-based model. J. King Saud Univ.-Comput. Inf. Sci. **34**(3), 687–697 (2022). https://doi.org/10.1016/j.jksuci.2020.01.008
25. Zhang, H.: Self-driving car scheduling method, car scheduling server, and self-driving car. US10409289B2 (2019)
26. Perkins, C.E.: Network address management for a wired network supporting wireless communication to a plurality of mobile users. US5159592A (1992)
27. Hu, Z., Yu, K., Sydorenko, V., Opirskyy, I.: Method for optimization of information security systems behavior under conditions of influences. Int. J. Intell. Syst. Appl. (IJISA) **9**(12), 46–58 (2017). https://doi.org/10.5815/ijisa.2017.12.05
28. Lewis, L.: Method and apparatus for component to service mapping in service level management (SLM). US7725570B1 (2010)
29. Gregus, M., Fedushko, S., Yu, S., Shurmelova, T., Steininger, E.: Service system of doctor's office. In: CEUR workshop proceedings. 2021. Proceedings of the symposium on information technologies & applied sciences (IT&AS 2021), Bratislava, Slovak Republic, vol. 2824, pp. 209–215 (2021)
30. Biyik, C., Allam, Z., Pieri, G., Moroni, D., O'Fraifer, M., O'Connell, E., Olariu, S., Khalid, M.: Smart parking systems: reviewing the literature. Arch. Ways Forward. Smart Cities **4**, 623–642 (2021). https://doi.org/10.3390/smartcities4020032
31. Liu, X., Liu, G., Wan, H.-D.: Innovation of smart city management system based on computer application technology. Lect. Notes Data Eng. Commun. Technol. **122**, 333–341 (2023). https://doi.org/10.1007/978-981-19-3632-6_41
32. Bolosky, W.J., Douceur, J.R., Ely, D., Theimer, M.: Feasibility of a serverless distributed file system deployed on an existing set of desktop PCs. ACM SIGMETRICS Perform. Eval. Rev. **28**(1), 34–43 (2000). https://doi.org/10.1145/345063.339345
33. Wang, C., Ren, K., Lou, W., Li, J.: Toward publicly auditable secure cloud data storage services. IEEE Netw. **24**(4), 19–24 (2010). https://doi.org/10.1109/MNET.2010.5510914

34. Yamada, K., Mizuno, M.: A vehicle parking detection method using image segmentation. Electron. Commun. Jpn. Part III Fundam. Electron. Sci. **84**(10), 25–34 (2001). https://doi.org/10.1002/ecjc.1039
35. Jemmali, M., Melhim, L.K.B., Alharbi, M.T., Bajahzar, A., Omri, M.N.: Smart-parking management algorithms in smart city. Sci. Rep. **12**(1) (2022). https://doi.org/10.1038/s41598-022-10076-4
36. Romantsova, N.V., Moshnaya, E.G., Fomenko, I.V.: Smart parking project for the smart city system 1581–1584 (2022). https://doi.org/10.1109/ElConRus54750.2022.9755706
37. Sibal, D., Jain, A., Jain, P.C.: Smart parking management system in smart city. Lect. Notes Electr. Eng. **771**, 1–9 (2022). https://doi.org/10.1007/978-981-16-2818-4_1
38. Jemmali, M., Melhim, L.K.B., Alharbi, M.T., et al.: Smart-parking management algorithms in smart city. Sci. Rep. **12**, 6533 (2022). https://doi.org/10.1038/s41598-022-10076-4
39. M. Holubčík, J. Jandačka, and J. Trnka, "Closed Cycle of Biodegradable Wastes in Smart Cities," EAI/Springer Innovations in Communication and Computing, pp. 59–73, 2023, doi: https://doi.org/10.1007/978-3-030-92968-8_4.
40. Paliwal, A.V., Shafiq, B., Vaidya, J., Xiong, H., Adam, N.: Semantics-based automated service discovery. IEEE Trans. Serv. Comput. **5**(2), 260–275 (2012). https://doi.org/10.1109/TSC.2011.19
41. Huang, A.-C., Steenkiste, P.: Network-sensitive service discovery. J. Grid Comput. **1**(3), 309–326 (2003). https://doi.org/10.1023/B:GRID.0000035168.31411.0c
42. Richardson, D.R., Cormie, J., Patel, I.S., Redman, B.W.S., Sheehan, R.: Request routing utilizing client location information. US8028090B2 (2011)
43. Bestmann, M., Cartier, J., Miltner, J.: Configuration of third party applications in a sandboxed environment. US9319270B2 (2016)
44. Nagel C.: Professional C# 7 and .NET Core 2.0. Wiley (2018)
45. Masse, M.: REST API design rulebook: designing consistent RESTful web service interfaces. O'Reilly Media, Inc. (2011)
46. hjp: doc: RFC 7523: JSON Web Token (JWT) Profile for OAuth 2.0 client authentication and authorization grants. https://www.hjp.at/doc/rfc/rfc7523.html. Accessed 01 Feb. 2020
47. Poniszewska-Maranda, D., Matusiak, R., Kryvinska, N., Yasar, A.-U.-H.: A real-time service system in the cloud. J Ambient Intell Human Comput **11**(3), 961–977 (2020). https://doi.org/10.1007/s12652-019-01203-7
48. Castro, P., Dockter, B., Divringi, L., Sundaresan, S.: Asynchronous database API. US7503052B2 (2009)
49. Hartig, O., Pérez, J.: Semantics and complexity of GraphQL. In: Proceedings of the 2018 World Wide Web Conference, Lyon, France, pp. 1155–1164 (2018). https://doi.org/10.1145/3178876.3186014
50. Bajaj, R., Ranaweera, S.L., Agrawal, D.P.: GPS: location-tracking technology. Computer **35**(4), 92–94 (2002). https://doi.org/10.1109/MC.2002.993780
51. hjp: doc: RFC 6455: The websocket protocol. http://www.hjp.at/doc/rfc/rfc6455.html. Accessed 01 Feb. 2020

Information Management Processes: Review of the State Open Data Web Portal

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Abstract This paper presents the investigation of the information management processes of Ukraine's government services. The review of the state open data web portal is carried out. The unified state web portal for open data is the Ukrainian government website, which was created to store public information in the form of open data and provide access to it to a wide range of persons according to the principles set out in the International Open Data Charter. The key portal task is to ensure free access to public information of the authorities and its further use. The main advantage of this portal is the ability for any user to copy, publish, distribute freely, or otherwise use the data posted on the portal. Including the use of open data for commercial purposes is allowed. The main task and capabilities of the state web portal for open data are placement by public authorities of open data and other information subject to disclosure; regular updating of current open data; providing general rules for the disclosure of open data for all users; ensuring the completeness, accuracy, and timeliness of published information; providing feedback and two-way communication with portal users. The unified state web portal for open data was created to implement the basic idea of open data: government accountability to citizens. The unified state web portal for open data can be called a big step towards modern, technological, and advanced solutions.

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Keywords Information management processes · Service · Government · Open data · Web portal

1 Introduction

At the time of worldwide globalization, the successful implementation of electronic government services testifies to the high level of development of the state, to the orientation of public services to the provision of high-quality services to its citizens.

The introduction of open data systems for almost all authorities gives citizens the opportunity to quickly obtain the necessary information and remotely use state services.

Lnenicka and Nikiforova [1] досліджують роль open data portals. Представили дослідження regions' open data portals [2] під час панедемії вчені Díez-Garrido and Lázaro, та Wu et al. [3].

Challenges and research opportunities of the open data portals представлено у дослідженнях Barcellos et al. [4], Diaz and Breux [5], Rodosthenous and Michail [6], Aslam [7], Randles and O'Sullivan [8], Urbanek and Schimmler [9], Al-khatib and Ali [10], Lim [11], and Criado et al. [12]. Krismawati and Hidayanto [13] study the user engagement of open data portal.

The process of the analysis and monitoring of national open data portals is presented by Raca et al. [14] and Milić et al. [15], Saxena [16], and G7 open government data portals [17]. The environmental justice through open government data investigated by through open government data [18], information security systems [19, 20], open government data portals and services [21–24].

The scientists also analyze the development and evolution of the open government data policy and portals in Taiwan [25], Saudi Arabia [26], Switzerland [27, 28], USA [29], Ghana [30], China [31, 32], Ireland [33], Pakistan [34], Brazil [35], Nigeria [36], Argentina [37] and process of conducting cross-country panel data analysis [38].

Analysis, development and modernization of information services and IT-technologies for governance [39–42] are also important for the functioning of state electronic services.

2 Review of the State Open Data Web Portal

The unified state web portal for open data is the Ukrainian government website, which was created to store public information in the form of open data and provide access to it to a wide range of persons according to the principles set out in the International Open Data Charter, which Ukraine joined in October 2016 year.

The portal was created at the request of the Law of Ukraine "On Access to Public Information" and resolution of the Cabinet of Ministers of Ukraine of October 21,

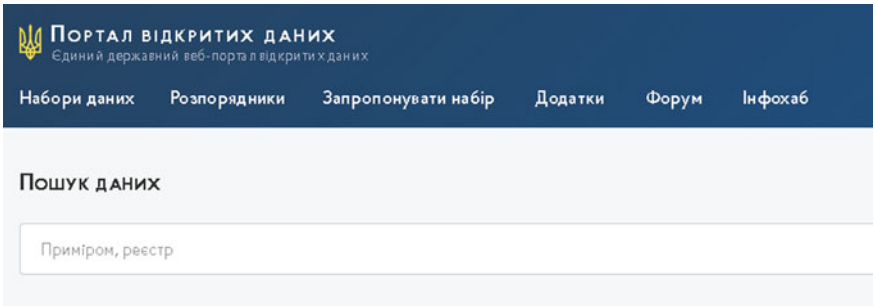

Fig. 1 Open data portal

2015 № 835 "On approval of the Regulations on data sets to be published in the form of open data." The portal task is to ensure free access to public information of the authorities and its further use.

Also, the main advantage of this portal is the ability for any user to copy, publish, distribute freely, or otherwise use the data posted on the portal. Including the use of open data for commercial purposes is allowed.

The main task and capabilities of the state web portal for open data are:

- placement by public authorities of open data and other information subject to disclosure;
- regular updating of current information (open data);
- providing general rules for the disclosure of open data for all users;
- ensuring the completeness, accuracy, and timeliness of published information;
- providing feedback and two-way communication with portal users.

Basic information on open data is clearly structured. The old page is shown in Fig. 1.

On the portal, user can find and find out all the information that is classified as open, news, and the latest data on monitoring the implementation of public legislation on open data.

It is also possible to send applications for various projects, and review the progress of orders and cases.

The site has useful links to state sites of Ukraine.

The site can be viewed in two languages—Ukrainian and English.

The unified state web portal for open data contains a lot of data, open and accessible to all. There is a lot of portal data, but it can be difficult to use, and the main problem is that not all information managers are registered on the site.

To provide free access to public information about the authorities and their further use is task of portal. This means anyone can copy, publish, distribute, or otherwise use the data posted on the portal. Including the use of open data for commercial purposes is allowed.

Official goals and capabilities of the unified state web portal for open data:

- placement by public authorities of open data and other information subject to disclosure;
- regular updating of current information (open data);
- providing general rules for the disclosure of open data for all users;
- ensuring the completeness, accuracy, and timeliness of the information published;
- providing feedback and two-way communication with portal users.

The unified state web portal for open data was created to implement the basic idea of open data: government accountability to citizens.

In this sense, the unified state web portal for open data can be called a big step towards modern, technological, and advanced solutions.

The next phase is the solution application and the possibility of its application. According to the established rules, information managers are obliged to publish the following data on the portal:

- Directory of telephone numbers and addresses
- Information on the organizational structure
- Report on the use of budget funds, including for individual budget programs
- Annual procurement plans
- Lists of administrative services, information cards of administrative services, and application forms required to apply for the provision of administrative services
- Administrative data collected by the information manager
- Legal acts subject to promulgation in accordance with the Law of Ukraine "On Access to Public Information."
- Financial reporting of economic entities of the public sector of the economy, which belong to the sphere of management of the information manager.

The portal contains the following sections:

- "Datasets"—information summarized according to certain parameters (total—30,450 datasets);
- "Managers"—information about information managers: central, local authorities;
- "Suggest a set"—the user can offer his data set for publication to the public on the portal. To organize this, choose a name for the data set, enter a description of the data set, indicate which organization is responsible for the data set, specify the website of the administrator, and write user message;
- "Applications"—a list of applications posted in the following sections: "Mobile application", "Chat bot", "Visualization". Also, the user can create their own application; for this user need to select the section, specify its name and link to the application, download the logo, add a description of the application;
- "Forum"—here users have the opportunity to ask questions about the work of the open data portal;
- "Infohab"—This section aims to provide information and public access to public data to citizens, government, and other organizations.

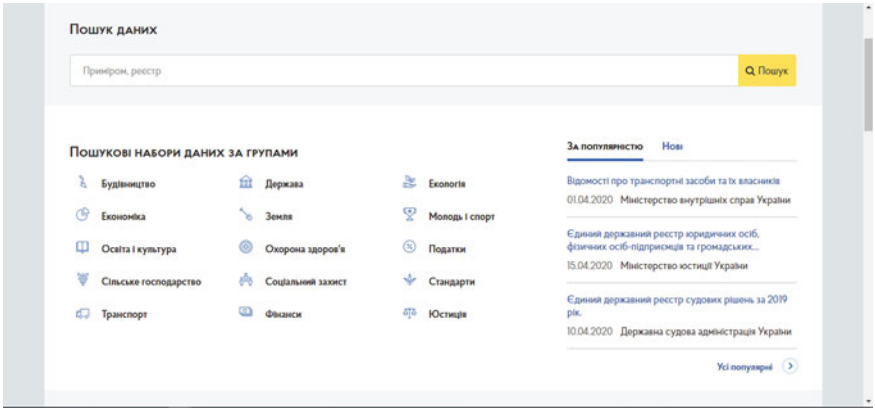

Fig. 2 Data sets by groups

It makes no sense to consider all these points in more detail, as the structure and data (information) presented are quite clear. Instead, it is important to present the main steps to find the correct information.

Item "Datasets"

The structure of the state web portal of open data systematizes all information by data sections, which, in turn, are divided into 15 categories (Fig. 2).

This data can be useful for both legal entities and individuals. Provided they are published in a timely manner and are easy to find and use.

In addition, in the section "Datasets" there are classifications and information, which are divided according to:

- Managers
- Group
- Keywords
- Formats
- Licenses

Here are some examples of obtaining information and working with the system.

Unified state register of persons to which the provisions of the law of Ukraine "On cleansing power" applied.

The Unified State Register of Persons Subject to the Provisions of the Law of Ukraine "On Purification of Power" (Figs. 3 and 4) is an electronic database containing information on persons subject to the prohibition provided for in part three or four of Article 1 of the Law of Ukraine "On Purification of Power." Holder of the Register—the Ministry of Justice of Ukraine. The Register Administrator is the State Enterprise Information Center of the Ministry of Justice of Ukraine.

Link to the main page of the service: https://lustration.minjust.gov.ua/register. Purpose of the service Processing information about persons subject to the prohibition

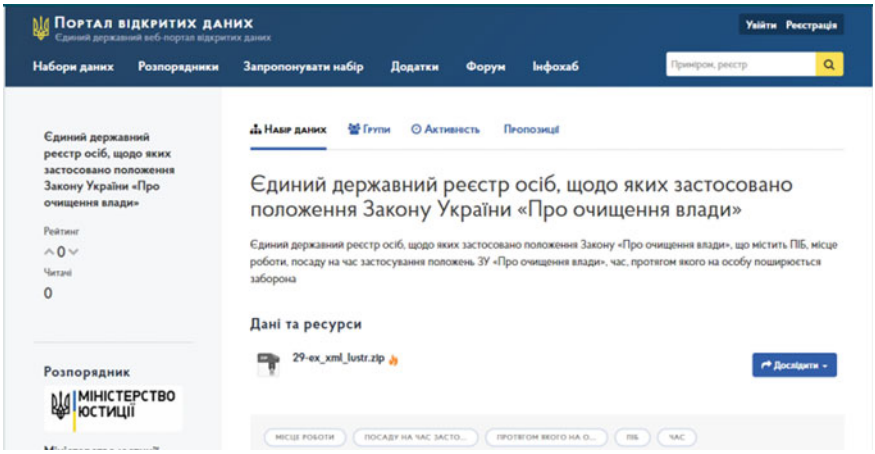

Fig. 3 Main page of Unified State Register of Persons, to which the provisions of the Law of Ukraine "On Purification of Power" are applied

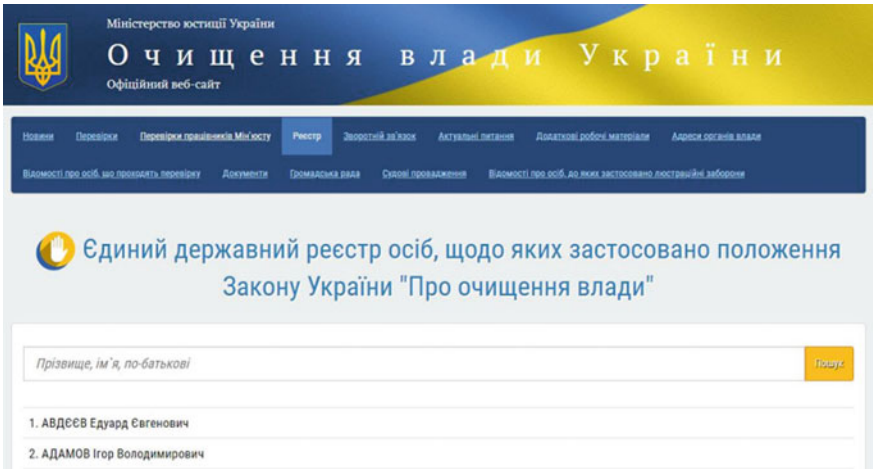

Fig. 4 List and search apparatus of persons to whom the provisions of the Law of Ukraine "On Purification of Power" have been applied

provided for in part three or four of Article 1 of the Law of Ukraine "On Purification of Power". Free access for those wishing to learn about persons who have violated the Law of Ukraine and to view the ongoing and those that have already been conducted.

Disadvantages of the service.

– news updates are not systematic;
– the site can be viewed only in Ukrainian—if a foreign person wishes to view the list of persons entered in the register—he will not be able to do so;

– when searching, be sure to enter the person's last name.

Advantages of the service.

– free access;
– fast functionality;
– the site is easy to use—all the necessary information is divided by size;
– availability of feedback;
– the ability to download and print the necessary data from the site;
– the registrar enters information into the Register no later than the third day after receiving the information to be entered into the Register;
– search in the register works even when only the person's last name has been entered.

Benefit citizens and professionals

This service is useful for citizens because it reflects the entire list of persons who have been entered in the register. They can also check to see if any of the employees performing duties in their hometown or village are listed. With the help of the feedback function (Fig. 5), those who wish can submit an application for verification of a specific person who was involved in fraud, and add (if available) video or photo materials that confirm this.

Experts can benefit from the service in that it contains all the necessary data on inspections of employees, judicial implementations, data on inspections of employees of the Ministry of Justice and in general persons holding positions in higher government bodies. The site is quite easy to use, all the necessary data that can be divided into groups on top of the panel for better search. The user can view the latest news on the issue of cleansing power.

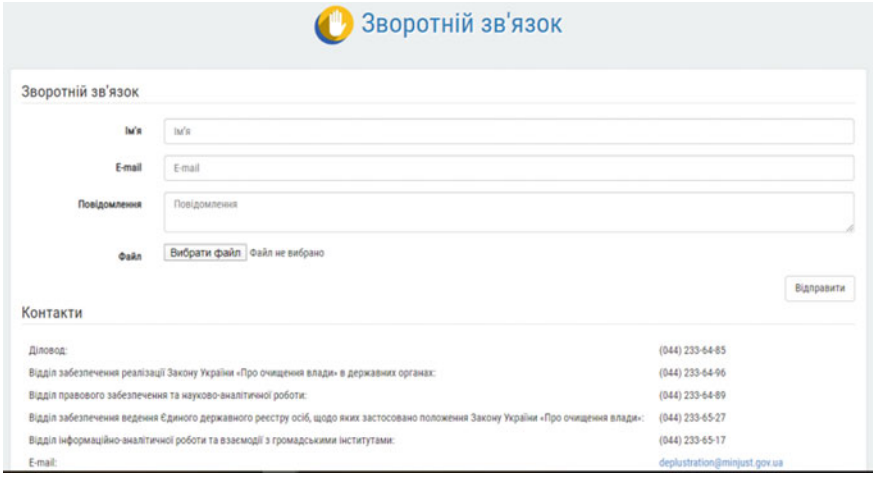

Fig. 5 Feedback

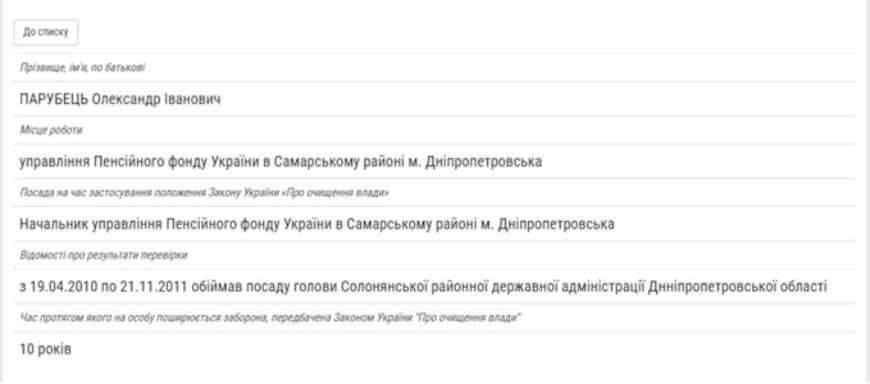

Fig. 6 Review of information about the person to whom the provisions of the Law of Ukraine "On Purification of Power" are applied

User can view the persons who are entered in the register through the application of the Law of Ukraine "On the cleansing of the power of Ukraine", as well as those persons who were subjected to lustration. There is also a search in the register (Fig. 6). As an attempt to investigate the correctness of the site, there was an attempt to search for "Sokil Maria Bogdanovna". This search did not yield results, which is not surprising, since this person is not an employee of the state apparatus. Accordingly, after searching for "Parubets Alexander Ivanovich" received the result shown in Fig. 6.

On the site user can also view the regulations related to the Law and view the orders, addresses, contacts of the authorities and the list of members of the public council for different years, including the past year.

Unified Register of Notaries.

On August 14, 2018, in accordance with the order of March 28, 2016 № 897/5 "On approval of the List of information to be published in the form of open data, managed by the Ministry of Justice of Ukraine" was created another e-democracy service open data portal—Unified Register notaries (Fig. 7).

The Unified Register of Notaries is a computer database containing information on state notary offices, state notarial archives and notaries of Ukraine.

There are 4 main sections on the portal page:

- data set;
- groups;
- activity;
- proposals.

The data set contains the latest updated registry file, which can be downloaded in zip format. Also, when user go to file research, a page opens with previous versions of the resource (Fig. 8).

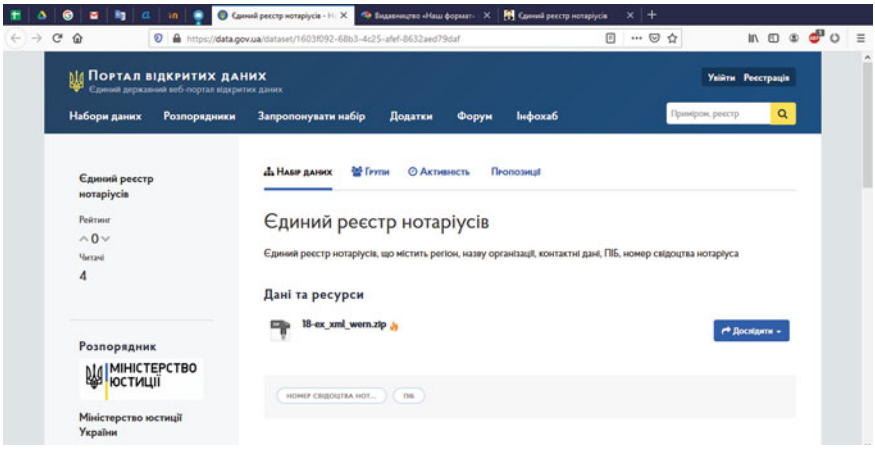

Fig. 7 The unified portal of notaries

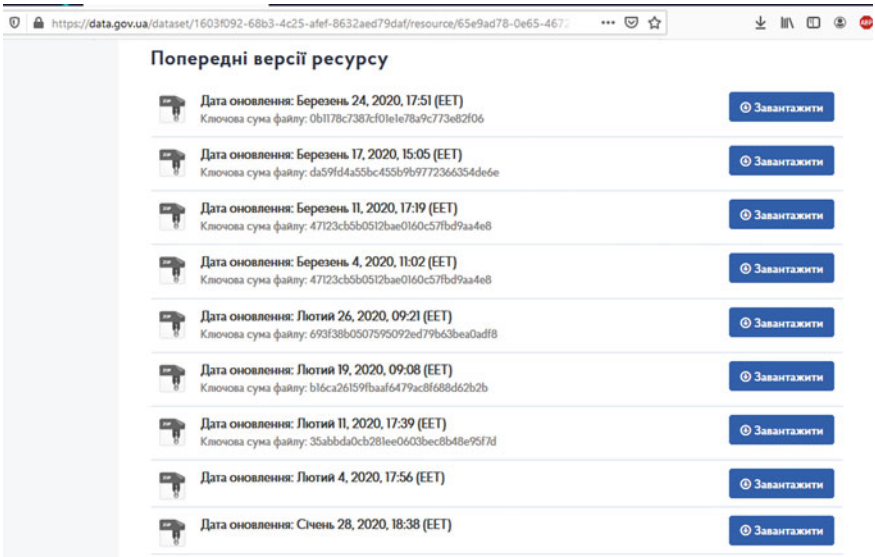

Fig. 8 A window with detailed information about the resources

It is worth noting that the update is released on average 3–4 times a month. In the Groups section it is possible to switch to other groups of documents related to the industry (Fig. 9).

In the Activity section user can see all the changes that have been made to the register (date, time and updated resource) (Fig. 10).

The section Proposals should contain suggestions entered by users on the operation of the portal, but unfortunately there were no suggestions.

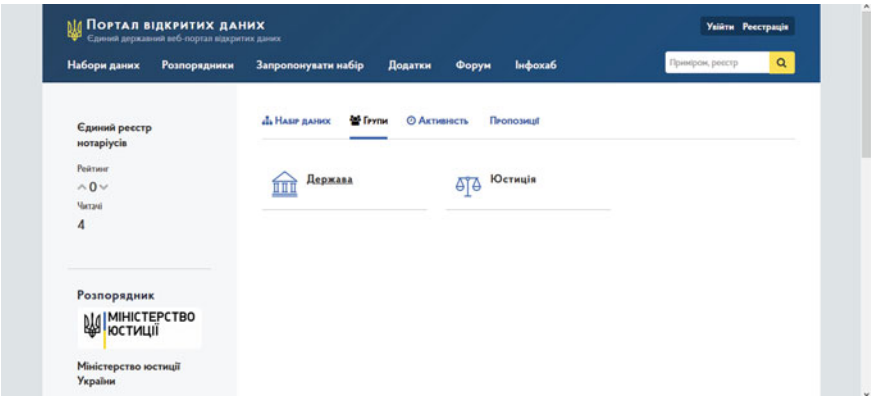

Fig. 9 Group section

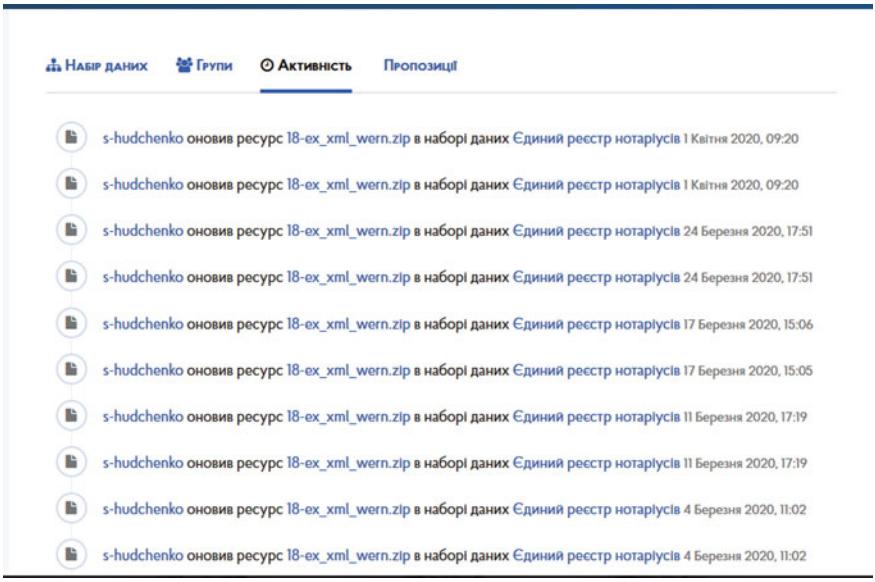

Fig. 10 Activities section

Requirements for the structure of data sets published on the portal:

The structure of the open data set includes a description of the composition (elements) of the data set, their format, parameters and purpose. The structure of the open data set is published in XSD, JSON, CSV or other similar formats.

The following formats are used when publishing data sets (Fig. 11).

It should be noted that the register is quite actively and periodically updated, but according to the statistics of the site there are only 4 active readers (Fig. 12).

Unified register of special forms of notarial documents is shown on the Fig. 13.

Текстові дані	TXT, RTF, ODT*, DOC(X), PDF (з текстовим змістом, не скановане зображення), (X)HTML*
Структуровані дані	RDF*, XML*, JSON*, CSV*, XLS(X), ODS *, YAML*
Графічні дані	GIF*, TIFF, JPG (JPEG)*, PNG*
Відеодані	MPEG, MKV, AVI, FLV
Аудіодані	MP3, WAV, MKA
Дані, розроблені в Macromedia Flash	SWF, FLV
Заархівовані дані	ZIP*, 7z*, Gzip*, Bzip2*

Fig. 11 Table of data formats

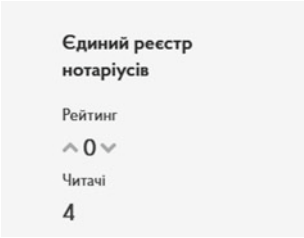

Fig. 12 Portal statistics

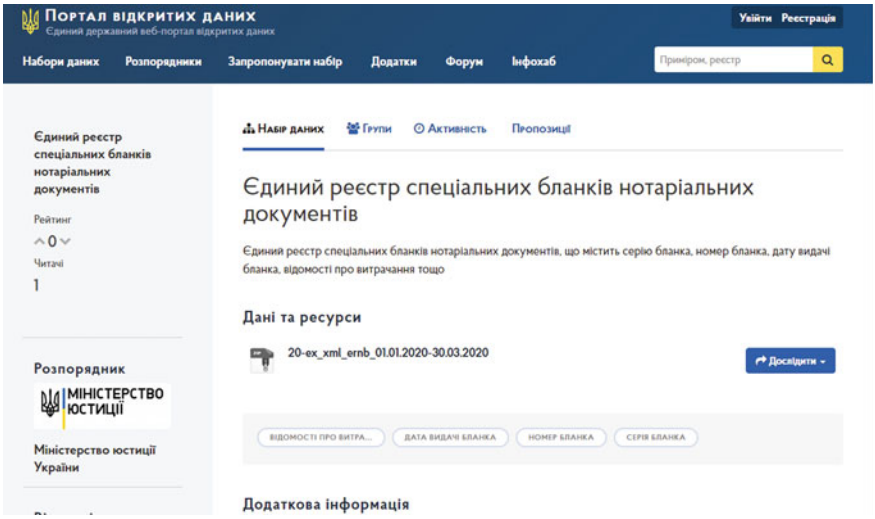

Fig. 13 Unified register of special forms of notarial documents

Managers

In this section user can get information about the list of Government agencies that have placed their Datasets.

In the “Managers” section of the site, managers are divided into:

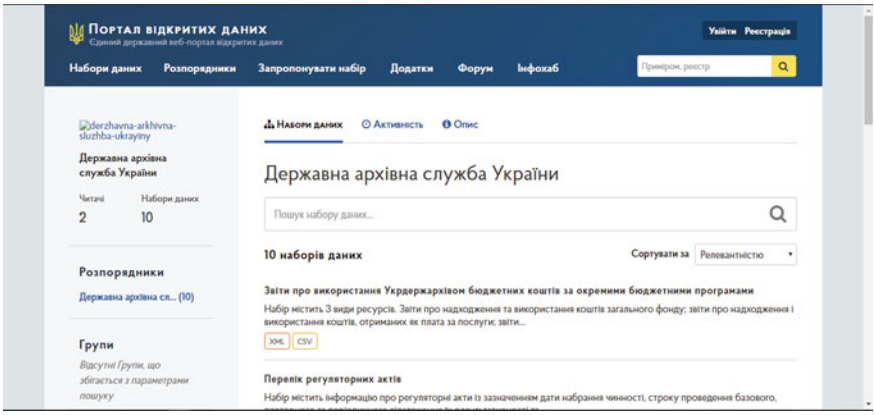

Fig. 14 Data set search

- Central (Verkhovna Rada of Ukraine, Ministries, State Services, State Agencies, State Inspectorates, CEBs with Special Status, Other Authorities, National Commissions, State Enterprises),
- local (administrators of all regions of Ukraine, as well as the Autonomous Republic of Crimea, Kyiv, Sevastopol),
- all together.

With the help of search we find on the portal data.gov.ua information manager of the State Archival Service of Ukraine. We see that 10 data sets were published on her behalf (Fig. 14).

Additions

"Applications" on the portal's website contains a list of various useful mobile applications, chatbots and visualizations, information about them and links to download. For example, the Medication Control app is a tool from the Ministry of Health of Ukraine that helps to find out all the details about the necessary medications right at the pharmacy window or in the doctor's office; Telegram BOT to obtain information on cars under the State number, as well as to receive Autocheck and Carfax reports for cars imported from the United States; Tabula is a handy and easy-to-use iOS application for litigation and litigation for practicing lawyers.

On the site user can find links to useful applications (Fig. 15).

"Infohab" section

The Infohab section provides us with informational representation and public access to open state data to citizens, state and other organizations. In this section user can find a lot of useful data regarding the data disclosure.

There user can find the following sections (Fig. 16):

- requirements for placement of sets;

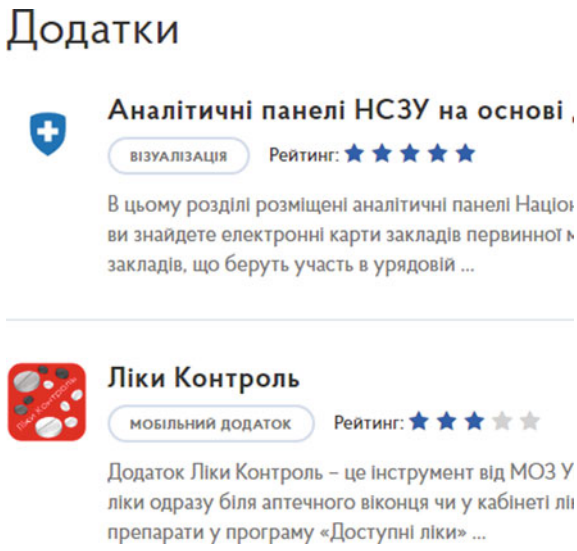

Fig. 15 Useful applications

Fig. 16 Infohab section

- recommendations for the publication of open data sets,
- instructions and information to managers,
- methodical materials,
- electronic training course on open data;
- information on accession to the International Open Data Charter;
- road map (Fig. 17),
- analytical module,
- the procedure for annual assessment of the state of publication and updating of open data.

Fig. 17 Map of open data development in Ukraine

On the site user can see a database with updates. But, for me personally, the information on the computer does not open after downloading. And there is no possibility to open at once in the browser (Fig. 18).

Fig. 18 Data on information updates

There is additional information (Fig. 19) that informs users that the information was updated literally this week.

User can also find instructions for users and administrators on the site. For regular users, this explains what open data is, what data formats are, and how to access a dataset. And for managers, the instructions are great. It already explains step by step how to fill in the fields of the registration form on the site as a manager. There is a link to download the full instructions (Fig. 20).

Also, the site specifies which formats should be used when publishing data. The data is presented in the table, with the specified formats for each data type (Fig. 21).

Додаткова інформація

Поле	Значення
Востаннє оновлено	Квітень 7, 2020, 16:29 (EEST)
Мета-дані востаннє оновлено	Квітень 7, 2020, 16:30 (EEST)
Створено	Серпень 14, 2018
Формат	ZIP
Ключова сума файлу	7db7c92815862e37c8179b0d3ca2c481

Fig. 19 Additional information

Інструкція

Інструкція по роботі з порталом для розпорядників .

Корисна інформація користувачам
Дізнайтеся, що таке відкриті дані, які існують формати відкритих даних та як отримати доступ через API.

Розпорядникам
Дізнайтесь, як зареєструватись на сайті та як розміщувати набори даних.

Fig. 20 Instructions

Тип даних	Формат даних
Текстові дані	TXT, RTF, ODT*, DOC(X), PDF (з текстовим змістом, нескановане зображення), (X)HTML*
Структуровані дані	RDF*, XML*, JSON*, CSV*, XLS(X), ODS*, YAML*
Графічні дані	GIF*, TIFF, JPG (JPEG)*, PNG*
Відеодані	MPEG, MKV, AVI, FLV, MKS, MK3D
Аудіодані	MP3, WAV, MKA
Дані, розроблені з використанням програми Macromedia Flash	SWF, FLV
Архів даних	ZIP*, 7z*, Gzip*, Bzip2*
Геопросторові дані	GeoTIFF, SHP, DMF, MID/MIF, DXF, XML, GeoJSON, GPX, LOC, ARINC, AIXM.

Fig. 21 Table of data types

It is easy to register on the site, there is a step-by-step instruction for proper registration. Everyone can take and add information. All user need to do is register correctly. In addition, the site has the opportunity to study.

Registration on data.gov.ua: instructions for users

The issue of publication by public information managers on the unified state web portal of open data data.gov.ua in accordance with the requirements of the Law of Ukraine "On Access to Public Information" of 13.01.2011 № 2939-VI requires additional comments. Information managers are obliged to provide public information in the form of open data on request, publish and regularly update it on the unified state web portal of open data and on their websites.

According to the Resolution of the Cabinet of Ministers of Ukraine of November 30, 2016 № 867 "Some issues of disclosure of public information in the form of open data" registration of information manager on the portal is carried out by the portal holder on the basis of the application for registration of information manager. The application for registration of the information manager on the portal is formed automatically when creating a personal electronic cabinet, then printed and certified by the signature and seal of the information manager or electronic digital signature of the manager and electronic digital seal of the information manager and sent to the portal holder—the State Agency for e-Government of Ukraine. The application form can be obtained during registration by downloading from the site data.gov.ua. To do this, on the main page in the upper right corner, click on the option "Personal Cabinet", then click on the option "Register".

Application for registration on the Unified State Web Portal of Open Data

As a result of the above steps, user will download the application form. User can see what this form of document (application) looks like below (Fig. 22).

The application form itself also contains information that in order to register and grant the relevant rights to the information manager on the unified state web portal of open data, it is necessary:

- fill in the form provided above;
- print and sign the generated document;
- send to the State Agency for e-Government of Ukraine;
- wait for confirmation of registration.

When entering information on the site during registration, it is also necessary to pay attention that the e-mail and contact phone number must be indicated not by the customer directly, but by the contact person who will be responsible for publishing the data sets. The holder of the portal on the basis of the issued application for registration of the information manager within three working days from the date of receipt of such application makes a decision on registration and granting appropriate access rights to the information manager on the portal. If the data contained in the application for registration of the information manager are incomplete and/or contrary to law, the portal holder within three working days from the date of receipt of such statement

Державне агентство з питань електронного урядування України

03150, м. Київ, вул. Ділова, 24

ЗАЯВА

про реєстрацію на Єдиному державному веб-порталі відкритих даних

Заявник _____ (повне найменування юридичної особи у відповідності до підтверджуючих документів)

Керівник _____
(посада, П. І. Б. керівника юридичної особи)

Адреса для листування _____ Телефон _____ Факс _____ E-mail _____ (телефон заявника) (факс заявника) (e-mail заявника)

Відповідальна особа _____ (посада, П. І. Б.)

Телефон _____ Факс _____ E-mail_____

(телефон відповідальної особи) (факс відповідальної особи) (e-mail відповідальної особи)

Прошу зареєструвати на Єдиному державному веб-порталі відкритих даних як розпорядника інформації, визначеного Законом України «Про доступ до публічної інформації».

_____ _____

(дата заповнення заяви) (підпис заявника) М. П.

Fig. 22 Application form for registration

informs the responsible person of the information manager about the need to eliminate inconsistencies information. Once user get the rights of information manager.

Next, to download the data set, user will need to follow the link to the personal account and select the "Add data set" tab, fill in all the required fields and click "Create". If all fields user correctly filled, a dataset passport will be created. If an error occurs, user will need to return to the stage of filling in the fields and check the correctness of all data entered. In addition, obtaining the right of information manager is accompanied by sending to users e-mail address (specified during registration) Instructions of the information manager of the unified state web portal of open data. So, as user can see, if user follow all the above actions, user will easily get the rights of information manager and the opportunity to publish users annual plans on the unified state web portal of open data.

The purpose of the service:

– ensuring the timely posting by the authorities of information to be made public, as well as any other data that meet the definition of public information in the form of open data;
– publication and regular updating by the administrator of information of open data on the portal;

- providing common information rules for all users of the information space on the disclosure of information materials in the form of open data;
- ensuring timely placement of complete and reliable information;
- providing effective two-way communications and feedback channels.

Benefits:

- timely placement of information is provided;
- all data are open and available to any citizen online;
- data are regularly updated, so users can be sure of the relevance of information;
- common rules for all users;
- providing effective two-way communications and feedback channels;
- any person is free to copy, publish, distribute, use, including for commercial purposes,
- different formats are used when publishing data sets;
- there are instructions for working with the portal for managers;
- there is a registration of the user and the administrator, separately;
- the functionality of the site can be easily intuitively understood;
- the site can be viewed in English;
- an action plan for the principles implementation of the International Open Data Charter was presented;
- An e-learning course on open data can be found on the website.

Disadvantages:

- in addition to the current site, there is an old version. Some users may inadvertently use outdated information;
- the site has very few visitors, which can be seen in groups in the "Readers" section;
- the discussion forum is inconvenient, the principle of work is not immediately understood.
- Many managers on the site have a progress rate of less than 20%. And a large number have a total of 0%.
- On the forum, many users write about the error when updating data.

Benefit citizens and professionals

The unified state web portal for open data provided at the moment is a necessity that is present in every democratic society. Every citizen has the access to information. And the single register of special forms of notarial documents is a necessary necessity for ordinary citizens and professionals.

The information on the site is the most up-to-date and timely, which allows people to work only with up-to-date information and not have problems with its use.

An e-learning course on open data can be found on the website. Information can be useful for both ordinary citizens and professionals. Training courses are free, beautifully and clearly designed. There is a video with a good picture and subtitles, where everything is clearly explained in simple language for people. It is also possible

to keep users result and continue learning by seeing progress; such an opportunity is given by registration. But user can study without it.

An action plan for the implementation of the principles of the International Open Data Charter and the percentage of implementation are presented. This gives citizens a better understanding of what the vector of development is now aimed at. But to be the initiator of the development of those segments that are not yet fully developed, or are just beginning their journey. It is also necessary for us to know where we are now.

And also so that enterprising people can see the situation, and in case of their desire and competence join the progress.

User can register on the site as a regular user and administrator. Such segmentation is very necessary and appropriate. This is to make the site work better depending on which user the person is registered with. This allows user to pull up the necessary functionality and give the most relevant answers.

Such a site is useful for the development of citizens in general. Because the need to visit such sites already speaks of an active position and participation of citizens in their own lives. But, unfortunately, on the site itself user can already see that traffic is low. This may be due to the fact that many users do not want to register, because almost all the information is available without registration on the site.

Functional analysis

The site is quite easy to use, all the necessary data that can be divided into groups on top of the panel for better search. The user can view the latest news.

The introduction of the portal had a positive effect on Ukraine's place in the international rankings of open data (Fig. 23):

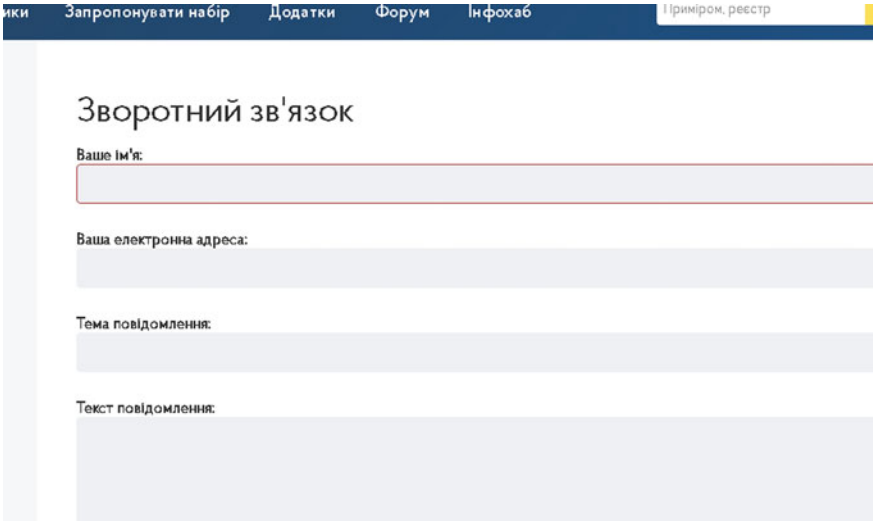

Fig. 23 Feedback form

– Ukraine rose 23 positions in the Open Data Index 2017 (31st place);
– Ukraine rose by 25 positions in the ranking of e-government compared to 2014 (62nd place out of 193 countries);
– increase of positions in the Open Data Barometer rating;
– 2016—44 places (18 positions higher than in 2015).

3 Conclusion

The result of this article is an analysis of the functionality, possibilities, advantages, and disadvantages of using the service of the Unified State Open Data Portal of Ukraine. It has been established that the main advantage of this portal is the possibility for any user to copy, publish, distribute freely, or otherwise use the data posted on the portal. The task and capabilities of the state open data portal are the placement of open data by authorities, regular updating of relevant information, provision of general rules for publicizing open data for all users, ensuring the completeness, reliability and timeliness of published information, providing feedback and two-way communication with portal users. The portal task is to provide free access to the public information about authorities and their further use. The single state open data web portal was created to implement the main idea of open data: government accountability to citizens. The single state portal of open data can be called a big step towards modern, technological, and advanced solutions. The service's shortcomings include that news is not updated systematically, the site can only be viewed in Ukrainian, and personalized search for people. However, the service has many advantages, such as free access, fast functionality, easy site use, feedback availability, and the ability to download and print the necessary data from the site.

References

1. Lnenicka, M., Nikiforova, A.: Transparency-by-design: what is the role of open data portals? Telemat. Inform. **61** (2021). https://doi.org/10.1016/j.tele.2021.101605
2. Díez-Garrido, M., Lázaro, M.M.: Transparency as a medicine. Communicating the pandemic through the autonomous regions' open data portals. Estudios Sobre el Mensaje Periodistico **28**(1), 65–80 (2022). https://doi.org/10.5209/esmp.77172
3. Wu, D., Ma, L., Zhang, H.: Evaluation of open health data portals for COVID-19 from the perspective of the user experience. Electron. Libr. **39**(2), 296–317 (2021). https://doi.org/10.1108/EL-01-2021-0011
4. Barcellos, R., Bernardini, F., Viterbo, J.: Towards defining data interpretability in open data portals: challenges and research opportunities. Inf. Syst. **106** (2022). https://doi.org/10.1016/j.is.2021.101961
5. Diaz, J., Breux, S.: Municipal open data portals: their implementation in the face of a municipality's political and territorial reality, vol. 46, no. 4/W1-2021, pp. 11–19 (2021). https://doi.org/10.5194/isprs-archives-XLVI-4-W1-2021-11-2021

6. Rodosthenous, C., Michail, D.: Enabling publishing and reuse of government data through the republic of Cyprus open data portal. Commun. Comput. Inf. Sci. **1537**, 292–303 (2022). https://doi.org/10.1007/978-3-030-98876-0_26
7. Aslam, M.: Using publications linked open data to define organizational policies. Int. J. Inf. Eng. Electron. Bus. (IJIEEB) **10**(5), 8–14 (2018). https://doi.org/10.5815/ijieeb.2018.05.02
8. Randles, A., O'Sullivan, D.: Assessing Quality of R2RML Mappings for OSi's Linked Open Data Portal, vol. 2977, pp. 51–58 (2021)
9. Urbanek, S., Schimmler, S.: A Translation Service for Open Data Portals, vol. 3049, pp. 113–119 (2021)
10. Al-khatib, B., Ali, A.: Linked data: a framework for publishing five-star open government data. Int. J. Inf. Technol. Comput. Sci. (IJITCS) **13**(6), 1–15 (2021). https://doi.org/10.5815/ijitcs.2021.06.01
11. Lim, T.: Patterns in environmental priorities revealed through government open data portals. Telemat. Inform. **64** (2021). https://doi.org/10.1016/j.tele.2021.101678
12. Criado, J., Jimenez, C., Alcaide-Munoz, L.: Open Data Portals Development in City Councils. An Empirical Analysis Based on Structural Factors in Spain, pp. 132–141 (2021). https://doi.org/10.1145/3463677.3463737
13. Krismawati, D., Hidayanto, A.N.: The user engagement of open data portal. Presented at the 2021 International Conference on Advanced Computer Science and Information Systems, ICACSIS 2021 (2021). https://doi.org/10.1109/ICACSIS53237.2021.9631357
14. Raca, V., Velinov, G., Cico, B., Kon-Popovska, M.: Application-based framework for analysis, monitoring and evaluation of national open data portals. Int. J. Adv. Comput. Sci. Appl. **12**(11), 26–36 (2021). https://doi.org/10.14569/IJACSA.2021.0121104
15. Milić, P., Veljković, N., Stoimenov, L.: Using OpenGovB transparency indicator to evaluate national open government data. Sustainability (Switzerland) **14**(3) (2022). https://doi.org/10.3390/su14031407
16. Saxena, S.: Invoking embeddedness and cybernetic theories for evaluating the national open government data portal of India. Inf. Discov. Deliv. **49**(4), 328–334 (2021). https://doi.org/10.1108/IDD-09-2020-0107
17. Mutambik, I., et al.: Usability of the G7 open government data portals and lessons learned. Sustainability (Switzerland), **13**(24) (2021). https://doi.org/10.3390/su132413740
18. Fusi, F., Zhang, F., Liang, J.: Unveiling environmental justice through open government data: work in progress for most US states. Public Adm. https://doi.org/10.1111/padm.12847
19. Hu, Z., Odarchenko, R., Gnatyuk, S., Zaliskyi, M., Chaplits, A., Bondar, S., Borovik, V.: Statistical techniques for detecting cyberattacks on computer networks based on an analysis of abnormal traffic behavior. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **12**(6), 1–13 (2020). https://doi.org/10.5815/ijcnis.2020.06.01
20. Hu, Z., Khokhlachova, Yu., Sydorenko, V., Opirskyy, I.: Method for optimization of information security systems behavior under conditions of influences. Int. J. Intell. Syst. Appl. (IJISA) **9**(12), 46–58 (2017). https://doi.org/10.5815/ijisa.2017.12.05
21. Criado, J., Jiménez-Cid, C., Alcaide-Muñoz, L.: To Adopt or not Adopt an Open Government Data Portal. Structural Motivations in Local Governments, vol. 3049, pp. 103–111 (2021)
22. Masoumi, H., Farahani, B., Aliee, S.: Systematic and ontology-based approach to interoperable cross-domain open government data services. Transform. Government People Process Policy **16**(1), 110–127 (2022). https://doi.org/10.1108/TG-08-2021-0132
23. Çaldağ, M.T., Gökalp, E.: The maturity of open government data maturity: a multivocal literature review. Aslib J. Inf. Manag. (2022). https://doi.org/10.1108/AJIM-11-2021-0354
24. Simonofski, A., Zuiderwijk, A., Clarinval, A., Hammedi, W.: Tailoring open government data portals for lay citizens: a gamification theory approach. Int. J. Inf. Manag. **65** (2022). https://doi.org/10.1016/j.ijinfomgt.2022.102511
25. Chen, T.T.-Y.: The developmental state and its discontent: the evolution of the open government data policy in Taiwan. Third World Q. **43**(5), 1056–1073 (2022). https://doi.org/10.1080/01436597.2022.2042801

26. Shehata, A., Elgllab, M.: Saudi scholars' perceptions and use of open government data portals at Shaqra University, Saudi Arabia. IFLA J. **47**(4), 493–504 (2021). https://doi.org/10.1177/03400352211023834
27. Valli Buttow, C., Weerts, S.: Open government data: the OECD's Swiss army knife in the transformation of government. Policy Internet **14**(1), 219–234 (2022). https://doi.org/10.1002/poi3.275
28. Fedushko, S., Ortynska, N., Syerov, Yu., Kravets, R.: E-law and E-justice: analysis of the Switzerland experience. In: International Workshop on Cyber Hygiene (CybHyg-2019), CEUR, vol. 2654, pp. 215–226 (2019). http://ceur-ws.org/Vol-2654/paper17.pdf
29. Begany, G., Martin, E., Yuan, X.: Open government data portals: predictors of site engagement among early users of Health Data NY. Government Inf. Q. **38**(4) (2021). https://doi.org/10.1016/j.giq.2021.101614
30. Egala, B., Afful-Dadzie, E.: Performance of open government data in a developing economy: a multi-stakeholder case analysis of Ghana. Transform. Government People Process Policy **16**(3), 318–333 (2022). https://doi.org/10.1108/TG-10-2021-0158
31. Zhang, H., Bi, Y., Kang, F., Wang, Z.: Incentive mechanisms for government officials' implementing open government data in China. Online Inf. Rev. **46**(2), 224–243 (2022). https://doi.org/10.1108/OIR-05-2020-0154
32. Jiang, H., Duan, Y., Zhu, Y.: Citizens' continuous-use intention to open government data: empirical evidence from china. In: Lecture Notes in Computer Science, LNCS, vol. 12988, pp. 64–78, (2022). https://doi.org/10.1007/978-3-030-96282-1_5
33. Khayyat, M., Aboulola, O., Khayyat, M.: How open is open? A study of two Irish open government data websites. Public Admin. Issues **5**, 30–44 (2022). https://doi.org/10.17323/1999-5431-2022-0-5-30-44
34. Khurshid, M., Zakaria, N., Arfeen, M., Rashid, A., Nasir, S., Shehzad, H.: Factors influencing citizens' intention to use open government data—a case study of Pakistan. Big Data Cogn. Comput. **6**(1) (2022). https://doi.org/10.3390/bdcc6010031
35. Demachki, É., Maricato, J.: Coverage of data sources and correlations between Altmetrics and citation indicators: the case of a Brazilian portal of open access journals. Ser. Rev. (2022). https://doi.org/10.1080/00987913.2022.2066967
36. Ezema, I.: Availability and access to open government data in Nigeria: a content analysis of government websites and Nigerian data portal. Int. Inf. Libr. Rev. (2022). https://doi.org/10.1080/10572317.2022.2061813
37. Indart, C., Hilario, A., Bravo, B.: Survey of open research data portals and repositories in Argentina. Informacion Cultura y Sociedad **45**, 59–74 (2021). https://doi.org/10.34096/ICS.I45.10421
38. Park, C., Kim, K.: Exploring the effects of the adoption of the open government partnership: a cross-country panel data analysis. Public Perform. Manag. Rev. **45**(2), 229–253 (2022). https://doi.org/10.1080/15309576.2022.2042703
39. Ho, D., Lee, Y., Nagireddy, S., Thota, C., Never, B., Wang, Y.: OpenComm: open community platform for data integration and privacy preserving for 311 calls. Sustain. Cities Soc. **83** (2022). https://doi.org/10.1016/j.scs.2022.103858
40. Hu, Z., Dychka, I., Onai, M., Zhykin, Yu.: Blind payment protocol for payment channel networks. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **11**(6), 22–28 (2019). https://doi.org/10.5815/ijcnis.2019.06.03
41. Carranza, J., Piumetto, M., Lucca, C., Da Silva, E.: Mass appraisal as affordable public policy: Open data and machine learning for mapping urban land values. Land Use Policy **119** (2022). https://doi.org/10.1016/j.landusepol.2022.106211
42. Giordano, V., Coli, E., Martini, A.: An open data repository for engineering design: using text mining with open government data. Comput. Ind. **142** (2022). https://doi.org/10.1016/j.compind.2022.103738

Investment Evaluation Methods for Business Performance

Monika Zatrochova and Ivan Katrencik

Abstract Business performance is one of the most monitored aspects of business management. There are many methods to measure performance. One of the areas of business performance is raising and creating capital and investments. The basic parameters monitored are risk, profitability, and liquidity. The company must know its costs and, within the framework of cost control, appropriately identify them and use them in decision making in production, financial, and investment activities. Investment is an integral part of every modern business. However, choosing the right investment may not always be easy. Static investment evaluation methods that do not take the time factor into account are sufficient for the initial investment evaluation. For a more accurate evaluation, dynamic methods are used that can accurately compare different investments in terms of the time distribution of income and costs over the life of the investment.

1 Introduction

Currently, the terms business performance and performance measurement are used relatively frequently. The content of these terms is not clearly defined. In the most general sense, the concept of business performance is used to define the very nature of the business's existence, its success, and its ability to survive in the future. According to Wagner [1] "*an enterprise's performance is a characteristic that describes how an enterprise carries out an activity in a similar way to the reference method of conducting the business, and the performance is interpreted by expressing the orderly relationship of the examined and reference modes of activity according to the criterion chosen and the performance of an enterprise is a characteristic that describes how an*

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enterprise carries out an activity in similarity to the reference method of conducting that activity, and the performance is interpreted by expressing the orderly relationship of the examined and reference modes of activity according to the selected criterion scale."

1.1 Basic Terms

The value of an enterprise is determined by its performance, and according to the theory of value management, an enterprise is an instrument whose task is to increase the capital of the owners. On the basis of this task, it is possible, in general, to define the concept of 'business performance' as the ability of an enterprise to best the value of the capital injected into the enterprise itself as well as into its business assets. The business is managed and at the same time bound by the interests of several stakeholders such as the interests of owners, investors, employees, customers, and creditors. Therefore, the performance of the company is also evaluated from various points of view focusing on the interests of the above entities [2].

Performance measurement can be a process that supports the development of a company by evaluating the analysis of performance indicators. It systematically tries to change towards maintaining long-term competitiveness. Business performance measurement approaches have undergone a long evolution. Some of them were formed more than fifty years ago, and others have been the subject of the last decade. As a result of theoretical concepts dealing with corporate governance and financial analysis, as well as pragmatic manners used in business practice, we consider a wide range of approaches to express business performance from the perspective of owners, which are formed during the development.

Performance measurement is essential for business management over a longer period of time. Create the basis to ensure the right direction for the implementation of the strategy. To ensure the success of the strategy, two basic issues must be addressed:

- continuously and systematically pay attention to the basic strategy of the company and the follower,
- focus on strategic performance and monitor:
  - what performance is achieved with the strategies currently being used,
  - whether the actual performance is comparable to the plan,
  - whether the current strategies are appropriate,
  - or the strategies need adjusters to make changes.

The basis of performance evaluation is to determine the indicators that the company wants to achieve—they represent the level of expected results. The following is a measurement of these indicators, or measurement of the actual results that the company achieves and comparison with the expected performance. The differences—deviations from the predicted values shall be identified and their causes determined. This is followed by the implementation of corrective actions, which

may have the characteristics of improving the implementation of individual activities, redirecting resources, changing performance indicators, or even correcting the strategy.

The problems of measuring the competitiveness of enterprises and finding methods for increasing it are crucial in research and scientific works by domestic and foreign authors. The aim of evaluating the competitiveness of a company is to find out the position of the company on the monitored market. Many definitions of business competitiveness have become a frequent term in the economic literature. Today, the represented complex of subproperties of objects (countries, businesses, industries, products) predetermine their success in the competition. They constitute a basis for entering the definition of the theoretical essence of business competitiveness that is important to expand with ecological approaches along with evaluation and at the same time focused on renewable resources.

In the economic literature and sources, the following methods are given to measure competitiveness of a company:

Measurement of Competitiveness by Multicriteria Evaluation. These methods synthesize several different attributes (indicators) into one integral indicator expressed by a particular number. They are classified as mathematical-statistical methods and can analyse the competitiveness of products in the selection of appropriate set of competitiveness indicators. The competitiveness analysis of the selected set of products is carried out through a calculated quantifier of competitiveness. They are useful for manufacturing companies.

1.2 Measurement of Business Performance with the BSC Method

The concept of the Balanced Scorecard method (BSC) is a strategic business performance measurement system that extends and connects the measurement of business performance from purely financial indicators to indicators of business activities in other areas. The objective of the BSC is a comprehensive "balance" between short-term and long-term business objectives, between value indicators and physical indicators, between delayed indicators and driving forces, and between internal and external performance factors.

Matrix Methods. They are based on an evaluation of company's marketing strategy using a matrix of competing strategies. We can find a similar approach, e.g., in the Ansoff matrix, the Thompson and Strickland matrix, the Boston Consulting Group matrix, and the McKinsey matrix. The shortcomings of this group of methods include the absence of development cause analysis as well as the demanding requirements for current and truthful information from the marketing environment of firms.

Managing a portfolio means identifying the positions of individual business units, analyzing the relationships between them, deciding on the support or decline of

business units based on the attractiveness of the industry and the competitive position, and designing strategies for entering or leaving the industry [3].

Methods Based on the Theory of Effective Competition. They are based on the fact that the most competitive companies are those in which the work of all branches and services is organized the most effectively. The basis of this approach is to evaluate the group indicators—competitiveness criteria.

Methods Based on the Tools of Marketing Mix. Business marketing and marketing research also create a knowledge base in the area or sector. Individual tools of the marketing mix and the components of microenvironment and macroenvironment influence the business activity and its activities related to the marketing research in terms of demand and sales which create an information based on the business processes that are not bound to traditional marketing functions like internal business evaluation, etc. Marketing research is thus an important part of the marketing information system. It provides relevant information and useful knowledge to decision makers in marketing. It also plays an important role in the creation and implementation of successful business strategies. The use of integrated marketing plays an important role in specifying, designing, developing, adapting, and innovating products according to the needs and wishes of customers. The issue of product policy, as well as other elements of the marketing mix, is essential to a successful a product launch.

Place is tightly connected with other tools of the marketing mix, e.g., character, speed, throughput, addressability and with others significantly contribute to the product competitiveness distribution path.

Promotion—the ever-growing information and communication opportunities identify new innovative methods, techniques and approaches [4, 5] and allow immediate approximation to the consumer, their thinking, needs, desires and decision-making. These new technologies have enabled the emergence of several innovative methods and contributed to the development of techniques used in marketing research to collect processes and analyze data. Existing methods of measuring the competitiveness of a business are often one-sided. Many of them will need to be transformed in the light of new innovation approaches, adapted to innovations that will contribute to ensuring the renewable sustainability.

1.3 Particular Measures Used for Measuring the Competitiveness of the Company

Within the performance measurement and competitiveness of the company, there are five basic specific measures that significantly affect the performance of the company. It is the input, output, efficiency, quality, and outcomes.

Input. The input measure monitors the amount of resources used to develop, maintain, or deliver a product, activity, or service.

Examples include:

- Money spent on equipment,
- Number of hour wages of the employees,
- Number of vehicles,
- Facility costs,
- Total operating expenditures,
- Rental fees,
- Number of full-time employees.

Output. The output measure monitors 'how much' was produced or provided. They provide a figure indicating how many items, referrals, actions, products, etc. were involved.

Examples include:

- Number of permits issued,
- Number of miles of pavement resurfaced,
- Number of people trained,
- Number of fixed water leaks,
- Number of cases managed,
- Number of arrests made,
- Number of documents processed,
- Number of clients served.

Efficiency. Efficiency measures are used to monitor the relationship between the amount produced and the resources used. This means that efficiency measures are created by comparing input and output. There are two general types of efficiency measures: unit cost and productivity. Unit cost is a comparison of an *input* to an *output* (i.e., resources used/produced). Productivity is a comparison of an *output* to an *input* (i.e., resources produced/resources used).

Examples include:

Unit Cost

- Cost per license issued,
- Cost per employee taught,
- Cost per paved lane-mile,
- Cost per client served,
- Cost per document.

Productivity

- Licenses processed per hour wages of the employee,
- Units produced per week,
- Students taught per instructor,
- Cases resolved per agent,
- Calls handled per hour.

Quality. Quality measures are used to determine whether customer expectations are being met. These expectations can take many forms, including timeliness, accuracy, meeting regulatory requirements, courtesy, and meeting customer needs. The expectations can be identified as a result of internal or external feedback.

Comparison of outputs is often used to create quality measures. It may be important to identify certain aspects (aspects/total outputs) about the services, products, or activities produced by an organization that are important to its customers. This comparison of specific outputs to total outputs is used to create measures of accuracy, timeliness, and to determine the extent of which regulatory requirements are met. Quality measures can also be derived from the evaluation of customer feedback data. See expressing measures with two or more variables [6].

Timeliness

- Busy signal rate,
- Percentage of driver licenses issued in one hour.

Accuracy

- Percentage of applications requiring rework due to internal errors,
- Taxpayer error rate on tax returns.

Requirements

- Percent of wells meeting minimum water quality requirements,
- Percentage of clients who rated themselves as successfully rehabilitated.

Meeting Customer Needs

- Percentage of customers who rated the service as good, very good, or excellent.

Outcome. The outcome measures and determine to what extent a core function, goal, activity, product, or service has impacted its intended audience. These measures are usually built around the specific purpose or result of the function, goal, service, product, or activity that is intended to be delivered or fulfilled. An outcome measure should show progress or achievement towards agency missions or goals (Fig. 1).

The Centre for International Competitiveness, founded in 2007 and focused on research of competitiveness of a company and economy, defines competitiveness as the ability of an economy to maintain increasing standards of living for

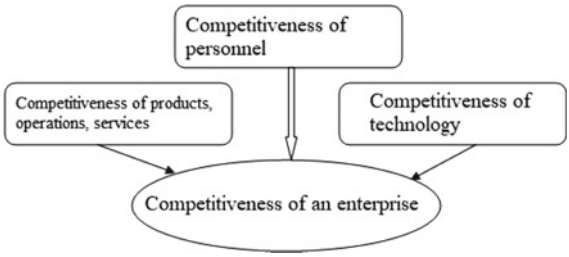


Fig. 1 Factors determining the competitiveness of an industrial enterprise [7]

those who participate in it, by attracting and maintaining firms with stable or increasing market shares in an activity [8]. Competitiveness in a region will depend on its ability to predict and successfully adapt to internal and external social and economic challenges, ensuring new economic opportunities, including higher quality workplaces.

Business performance measures are indicators used in recent years in countries with the most advanced capital markets to measure performance in the direction of maximizing shareholder value. The common features of these indicators are the following:

- The use of occasional costs, i.e. missed opportunity costs, in the form of capital costs (WACC) Operating profit/loss (NOPAT) is used as a profit indicator.
- In practice, the following indicators are most commonly used:
  - EVA (Economic Value Added)—currently the most widespread,
  - CFROI (Cash Flow Return on Investment)—CF return on investment,
  - CROGA (Cash Return on Gross Assets)—CF return on gross assets,
  - MVA (Market Value Added),
  - RONA (Return on Net Assets)—return on net assets.

2 Capital and Investments

Corporate finance is the division of finance that deals with how corporations cope with funding sources, capital structuring, and investment decisions. Corporate finance is primarily concerned with maximizing shareholder value through long and short-term financial planning and the implementation of various strategies. Corporate finance activities range from capital investment decisions to investment banking.

Capital financing is a balancing act in terms of deciding on the relative amounts or weights between debt and equity. Having too much debt may increase default risk and relying heavily on equity can dilute earnings and value for early investors. In the end, capital financing must provide the capital needed to implement capital investments.

2.1 Basic Terms

Capital is an essential term that defines the financial resources of the company to ensure basic operations. If we had to divide capital, we can do it from different perspectives:

- By the way it has been contracted;
- By the ownership;
- By the usable period.

By the Way it has been Contracted. We can divide capital into internal and external. Internal capital, which has been created by company activities (write-offs, reserves) and external capital, which has been contracted from company owners and other subjects.

By the Ownership. Company's own capital—contracted from owners and extraneous—contracted from lent sources.

By the Usable Period. *Permanent capital* (available unlimitedly within long period) and *temporary capital*—available for the period shorter than 1 year—short-term or long-term for more than 1 year.

Capital makes up the company's finance resources with the so-called corporate finances deal. Corporate finances are an economic category, and their own status derives from their sphere of operation in accordance with their function. In the environment of market mechanism, the existence of corporate finances is conditioned by commodity—monetary relations and effects of the Law of Value, Law of Supply and Law of Demand.

In order to fulfil the aims of business activities, the company comes across various relationships with different subjects in many spheres of its activities. Relations related to finances are one of the most important. Monetary relations can be classified by various characteristics in accordance with the purpose of research related to them. The basic monetary relations of the company according to various classification features are listed in Table 1.

All these relations are essential for the company itself, and they help to complete the understanding of the existence and creation of the capital in it. Regarding company performance, a crucial aspect is capital ownership, which can greatly influence the performance of the company. If there is more external capital than the internal one, it is clear that it is associated with the interest costs, which are paid from the capital. It is also clear that external capital is cheaper than our own and regarding its possession it is suitable for the company to have rather external capital than internal (gold rule

Table 1 Classification of monetary relations of an industrial enterprise [9]

According to the characteristics of monetary relations	Realizable monetary relations; Budgetary monetary relations; Credit monetary relations; Security monetary relations; Insurance monetary relations
According to the entities among which monetary relations arise	Monetary relations with the external environment; Internal monetary relations of the company
According to the area of business activity in which monetary relations arise	Relations for gaining financial support; Relationships in the assignment of financial resources in individual components of assets; Relations related to the realization of production and the use of production factors; Relationships that ensure the distribution of the achieved economic results

of financing). We also know that our own capital is more expensive than the external one, because it is created within the company subtracted from all the costs for the employees, input arrangement, etc. Regarding own capital, number of dividends is crucial, alternatively profit shares, which would be demanded by the owners. All these affect its performance. It must be considered that if the owners want to achieve a company in good condition, it should be paramount for them to have their invested capital working. Thus, circulating in the company and having sufficient turnover.

2.2 Basic Categories of Financial Decision-Making

Basic categories, which are used to evaluate the company's performance, are:

- Economic results,
- Cash flow,
- Value of money in time,
- Interest and interest rate,
- Entrepreneurial risk,
- Costs of alternative opportunities.

All these categories are a part of the company's finances and are primarily part of the company's financial management. Financial decisiveness is here to find the best ways to fulfil the financial goals of the company.

Regarding the evaluation of company performance, we will pay attention to these indicators:

Profit represents the difference between revenues and costs:

$$\text{Profit} = \text{Revenues} - \text{Costs}. \tag{1}$$

Through financial results, the company's performance can be clearly defined. The results of the company's economy are planned, monitored, and analyzed with respect to particular activities before and after tax is deducted:

- Economic results of business activities (Pba)
- Economic results of financial activities (Pfa)
- Economic results of operational activities (Poa = Pba + Pfa)
- Economic results of extraordinary activities (Pea).

$$\text{Profit after Tax (Net Profit, Net Income)} = (\text{Pba} + \text{Pfa} + \text{Pea}) * (1 - \text{Tax}). \tag{2}$$

Therefore, the economic results can be as follows:

- $P > 0$ profit,
- $P < 0$ loss,
- $P = 0$ null, balanced.

Cash Flow. Cash flow of the company (CF) is an essential category used for decision-making about the solvency of the company and for investment decisions, which allow us to determine the company's performance over a period of time. We consider CF as growths and declines in financial means and financial equivalents. Financial flows are planned, monitored, and analysed regarding these activities of the company:

- Operational activities,
- Investment activities,
- Financial activities.

Regarding the performance of the company, financial and investment CF are important because the performance itself is materialized and measurable in the form of money volume. Just to remind everyone, CF represents only the inflow and outflow of money; therefore, it is defined as positive and negative cash flow. The methods used for its calculations are direct and indirect methods of CF calculations.

Preparing the Cash Flow *as per the Direct Method*, items like Depreciation, Amortization of Intangible Assets, Preliminary Expenses, Debenture Discount, etc. are ignored from Cash Flow Statement since the Direct Method includes only Cash Transactions and Non-Cash Transactions are omitted. While preparing the Cash Flow Statement as per the *Indirect Method*, the Net Profit/Loss for the period is used as the base, and then adjustments are made for items that affected the Income Statement but did not affect the Cash. It means that Non Cash charges in the Income Statement are added back to the Net Profits.

2.3 Entrepreneurial Risks

Entrepreneurial risk is an irreparable part of entrepreneurship. It depicts the level of risk and uncertainty. Uncertainty is a certain value, which defines the probability of occurrence of phenomena in a certain interval, e.g. cyclic economic crisis, when the currency drops. The risk associated with entrepreneurial risk has its positive and negative sides. The negative side is associated with fear of loss or termination. On the other hand, a positive one affects the business subject motivationally, for example, to achieve profit, company development, or improvement in its performance.

Factors affecting entrepreneurial risk:

- *external*—mostly in the form of macroeconomic causes (changes in the tax, customs system, inflation, changes in currency exchange rate, uniting of the companies, etc.),
- *internal*—causes regarding the personality of the entrepreneur (focusing on short-term problems, innovation unwillingness, overrating of assumed effects, bureaucracy growth in the company management).

The entrepreneurial risk itself is an option, whether achieved business results will be deflected in a favorable or unfavorable way from expected results. The level of

risk is assessed on the basis of an analysis of the determinative deviation and the coefficient of variation [10].

The determinative deviation (σ) is used when the average expected results ($\overline{P}$) of the possibilities are the same. The higher the determinative deviation, the higher the entrepreneurial risk.

The coefficient of variation (V_c) is used for different weighted average expected results of the analysed variants.

$$\sigma = \sqrt{\sigma^2}. \tag{3}$$

$$\sqrt{\sigma^2} = \sum_{j=1}^{N} \left(P_j - \overline{P}\right)^2 * v_j. \tag{4}$$

$$\overline{P} = \sum\nolimits_{i=1}^{n} P_i * v_i. \tag{5}$$

$$V_c = \frac{\sigma}{\overline{P}}. \tag{6}$$

After analyzing the risk, the company itself must take the initiative to reduce it. It can be implemented in different ways:

- diversification of business activities,
- flexibility,
- risk division,
- transfer of the risks,
- insurance.

Diversification of Business Activities. It is a matter of dividing the business into several activities, and it can also be several areas of industry, where in case of failure of one area, its losses will be covered by another area, which is thriving.

Flexibility. It represents the flexibility and adaptability of the business area. If given area is thriving, we are able to adapt for supplying bigger amounts of goods to the market, if it does not prosper, we can relatively diversify the given business area, then expand this area and find a more profitable part of it. For example, a dairy company, which has been producing basic products only (milk, yoghurts, cheese), will expand its business to include the production of flavored milks and lactose-free products—a case of related diversification that will increase the company's performance.

Risk Division. It is meant in such a way that we do not handle the risk of business ourselves, but we share it. For example, in the case of a massive order, two companies cooperate so that it can be fulfilled, and in the case of a risk, it is handled by both companies. If the plan fails, it is not fatal for both companies. Also, if they did not share the risk, they would not be able to implement the contract.

Transfer of Risks. We transfer part of the entrepreneurial risk on another subject, e.g. subcontractor.

Insurance. Is a natural protection from a risk and an effective form of formation and reallocation of monetary funds. It is provided by an insurance company based on so-called insurance relations. Insurance is a contractual relationship between the insured person and the insurance company, in which the insurance company undertakes to provide the insurant in the event of an insurance casualty. Thus, part of the risk is taken over by the insurance company for a fee. Insurance works on the principle of conditional return (only in the event of casualty) and inequivalence (the amount paid in the event of casualty does not correspond to what the insured person paid in the form of premium).

2.4 Financial Analysis

Financial analysis is the process of evaluating businesses, projects, budgets, and other finance-related transactions to determine their performance and suitability. Typically, financial analysis is used to analyze whether an entity is stable, solvent, liquid, or profitable enough to warrant a monetary investment.

Financial analysis is used to evaluate economic trends, establish financial policy, develop long-term plans for business activity, and identify projects or companies for investment. This is done through the synthesis of financial numbers and data. A financial analyst will thoroughly examine financial statements of a company; the income statement, the balance sheet, and the cash flow statement. Financial analysis can be conducted in both corporate finance and investment finance settings.

One of the most common ways to analyze financial data is to calculate ratios from the data in the financial statements and compare them against those of other companies or against the company's own historical performance.

Corporate Financial Analysis. In corporate finance, the analysis is conducted internally by the accounting department and is shared with management to improve business decision making. This type of internal analysis may include ratios such as the net present value (NPV) and the internal rate of return (IRR) to find projects worth executing.

Investment Financial Analysis. In investment finance, an analyst outside the company performs an analysis for investment purposes. Analysts can conduct either a top-down or bottom-up investment approach. A top-down approach first looks for macroeconomic opportunities, such as high-performing sectors, and then drills down to find the best companies within that sector. From this point, they further analyse the stocks of specific companies to choose potentially successful ones as investments by looking last at a particular company's fundamentals.

A bottom-up approach, on the other hand, looks at a specific company and conducts a similar ratio analysis to the ones used in corporate financial analysis, looking at past performance and expected future performance as investment indicators. Bottom-up investing forces that investors consider are first and foremost microeconomic factors. These factors include a company's overall financial health, analysis

of financial statements, the products and services offered, supply and demand, and other individual indicators of corporate performance over time.

Fundamental Analysis. Fundamental analysis uses ratios gathered from data within the financial statements, such as a company's earnings per share (EPS), in order to determine the business's value. Using ratio analysis in addition to a thorough review of the economic and financial situations surrounding the company, the analyst can arrive at an intrinsic value of the security. The final goal is to arrive at a number that an investor can compare with a security's current price in order to see whether the security is undervalued or overvalued.

Technical Analysis. Technical analysis uses statistical trends gathered from trading activity, such as moving averages (MA). Essentially, technical analysis assumes that the price of a security already reflects all publicly available information and instead focuses on the statistical analysis of price movements. Technical analysis attempts to understand the market sentiment behind price trends by looking for patterns and trends rather than analyzing the fundamental attributes of a security.

Vertical Analysis. This type of financial analysis involved looking at various components of the income statement and dividing them by profits to express them as a percentage. For this exercise to be most effective, the results should be benchmarked against other companies in the same industry to see how well the company is performing. This process is also sometimes called a common-size income statement, as it allows an analysis to compare companies of different sizes by evaluating their margins instead of their value.

Horizontal Analysis. Horizontal analysis involves taking several years of financial data and comparing them with each other to determine the growth rate. This will help an analyst determine whether a company is growing or declining and identify important trends. When building financial models, there will typically be at least three years of historical financial information and 5 years of forecast information. This provides eight years of data for performing a meaningful trend analysis, which can be benchmarked against other companies in the same industry.

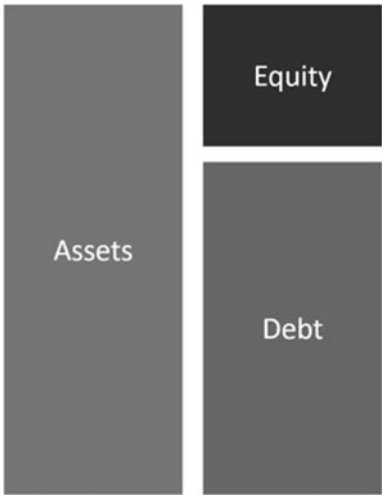
Leverage Analysis. Leverage ratios are one of the most common analytical methods used to evaluate the performance of a company. A single financial metric, such as total debt, may not be that informative on its own, so it is helpful to compare it with total equity to get a full picture of the capital structure. The result is a debt-to-equity ratio.

Common examples of ratios include the following:

- Debt/equity;
- Debt/EBITDA (Earnings before Interest Taxes Depreciations and Amortizations),
- EBIT/interest (interest coverage),
- Dupont analysis: a combination of ratios, often referred to as the pyramid of ratios, including leverage and liquidity analysis.

$$\text{Return on Equity(ROE)} = \text{Net profit margin(NPM)} * \text{Asset Turnover} * \text{Equity Multiplier}. \tag{7}$$

Fig. 2 Financial leverage



$$\text{ROE} = \frac{\text{Net Income}}{\text{Sales}} * \frac{\text{Sales}}{\text{Assets}} * \frac{\text{Assets}}{\text{Shareholder's Equity}}. \tag{8}$$

The dependence of the mentioned relations is expressed in the following Fig. 2.

Growth Rates. Analyzing historical growth rates and projecting future growth rates is an important part of any financial analyst's job. Common examples of analysing growth include:

- Year-over-year analysis,
- Regression analysis,
- Bottom-up analysis (starting with individual drivers of profits in the business),
- Top-down analysis (starting with market size and market share),
- Other forecasting methods.

Return Rates. At the end of the day, investors, lenders, and finance professionals, in general, are focused on what type of risk adjusted return rate they can earn on their money. As such, assessing rates of return on investment (ROI) is critical in the industry.

Common examples of return rate measures include:

- Return on Equity (ROE),
- Return on Assets (ROA),
- Return on invested capital (ROIC),
- Dividend Yield,
- Capital Gain,
- Accounting rate of return (ARR),
- Internal rate of return (IRR).

$$\text{ROA} = \frac{\text{Net Income}}{\text{Total Assets}}. \tag{9}$$

$$\text{ROIC} = \frac{\text{NOPAT}}{\text{Invested Capital}} = \frac{\text{Net Operating Profit after Tax}}{\text{Invested Capital}}. \tag{10}$$

$$\text{Dividend Yield} = \frac{\text{Annual Dividends per Share}}{\text{Price per Share}}. \tag{11}$$

Within the description and examination of financial-economic analysis, there are many views and types of analysis. In this textbook, only selected ones are mentioned which are related to the sustainability of the company and ensure the competitiveness of the company.

3 Costs and Prices

The costs of a company can be defined as a monetary assessment of the consumption of production factors expended for its performance (products, works, or services) and other purposefully outlaid expenditures associated with its activity. They function as financial means, which were used to ensure the necessary products, works, and services as a result of the production and business processes [11].

3.1 Basic Terms

Costs are monetary expression of living and materialised work which has been used for particular performance, that is, for production of goods, work execution or performing of a service. Cost is therefore only paid and materialised work in a given accounting period, which is used up at the same accounting period.

Expenditure—physical loss of property (e.g. expenditure of material from the warehouse).

Disbursement—decrease in funds (specific type of expenditure).

For the sake of performance measurement of the company and securing its competitiveness, basic economic goals are in force:

1. *Profit achieving*—it is an essential condition for future existence and development of the company.
2. *Securing financial stability and liquidity of the company* (the company is well-financed and has enough financial resources to protect its commitments).
3. *Yield situation*, that means securing efficiency of manufacturing and other activities—relations between outputs and inputs are measured by:

   a. Maximization of output at given inputs,

b. Minimalization of inputs at given outputs,
c. Optimization of the relations between inputs and outputs.

3.2 Classification of the Costs

Cost classification is the creation of groups of costs with individual characteristic traits in order to have certain peculiarities occurring in only one group. The reason why we divide costs is that information on total (global) costs can be used only to a limited extent, and for a wider practical use, it is purposeful to break down costs from various points of view.

In practice, the most frequently used classifications of total costs are the following:

1. According to types of expenses (economic, respectively division by different types),
2. According to accounting requirements (for enumeration of the economic results),
3. According to the items in the calculation formula (calculation classification),
4. Depending on the volume of performance.

Economic Costs Classification (according to types). There are several types of costs associated with doing business, e.g. consumption of different types of materials, wear and tear of fixed assets, employee wages, energy consumption, etc. Classification by type is an essential cost classification. It is based on the division of total costs regarding criteria of economic homogeneous types, and the characteristic trait of it is the economic unity of each cost item. Therefore, each of them contains just one type of cost, no matter where it is used and what is the purpose of it.

Classification of costs according to type:

- Consumed purchases (material, energy, gas, water),
- Services bought and used (machine repair, travel expenses, advice),
- Salaries and other personal expenses (wages, statutory social insurance),
- Taxes and fees (road tax, real estate tax),
- Corporate income tax,
- Other costs from economic activities (donations, fines, penalties),
- Financial costs (interest paid, exchange rate losses, bank fees),
- Creation of the reserves,
- Other types of costs.

In terms of origin, we divide the costs into:

1. **Primal**. *Characteristics*: are reported for the enterprise as a whole, arise with the consumption of external performances and are accounted for the first time (e.g. supplier invoice for the electricity), are reported in the same form as they originated, it is not taken into account where they originated (in what department) or for what purpose they were spent, are simple costs—each cost element forms one unit (they do not consist of components).

Use: are used to quantify the economic results of the company as a whole, to compare the structure costs,

2. **Secondary**: *Characteristics*: represent the consumption of outputs of internal organisational units, are complex costs, which can be decomposed into original primary costs types, arise from the consumption of its own performance (e.g., when a company produces electricity and uses it in its own production).

   Use: is used for cost management according to internal departments.

Costs in terms of *production volume* are valuable to be monitored in the following aspects:

- To find out economic results,
- Exploring reserves to lower costs,
- Documents for planning costs for future periods,
- Documents for setting prices.

The procedural concept of costs is shown in Fig. 3.

Total costs are always the sum of individual items in a certain breakdown of costs, expressed by the following formula:

$$\text{Total Costs (TC)} = \text{Fixed Costs (FC)} + \text{Variable Costs (VC)} \tag{12}$$

The relations between total costs, fixed costs and variable costs are shown in Fig. 4.

Fixed Costs. Fixed costs are in the performance amounts rather independent, they exist even when no performance is in place and are called readiness costs, e.g., depreciation of buildings, machinery, rent, administrative overheads, etc. These are also costs that do not change when the volume of production changes or changes in leaps (e.g., when purchasing tangible fixed assets).

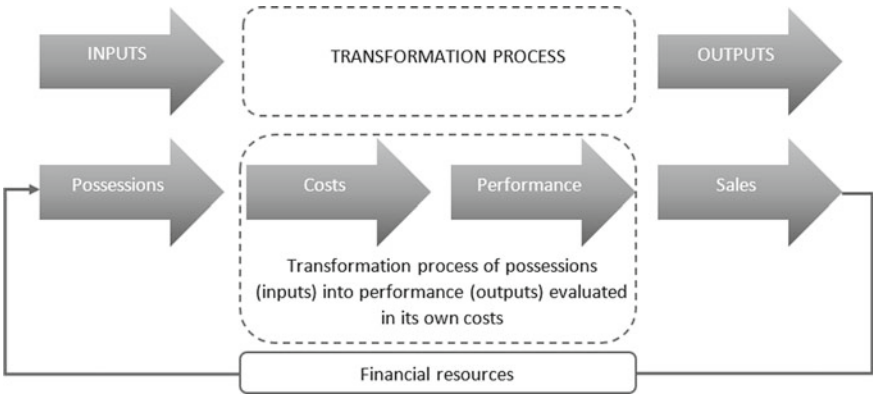


Fig. 3 The procedural concept of costs [12]

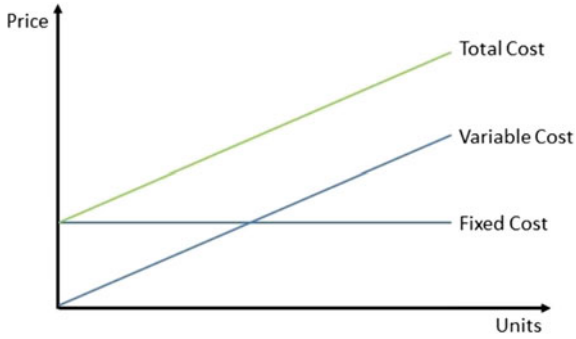


Fig. 4 Costs in terms of production volumes

When production capacity is not used, there are no fixed costs. Part of the total fixed costs that correspond to the unused production capacity is called unused (free) fixed costs. Although it is a theoretical division of fixed costs (in fact, fixed costs are not divisible because they are associated with the need to ensure the functioning of the company as a whole), they provide important information on the effectiveness of fixed costs. Figure 5 illustrates absolute and relative fixes costs depending on the production volume.

Variable Costs. The basic characteristics of variable costs are:

- Their amounts depend on the change of performance volumes,
- costs, whose volume depends on changes in the performance volumes, more or less in proportion to its increase or decrease,
- are named movable or variable costs—VC,
- for example, consumption of basic and auxiliary materials, wages of production workers, and energy consumption.

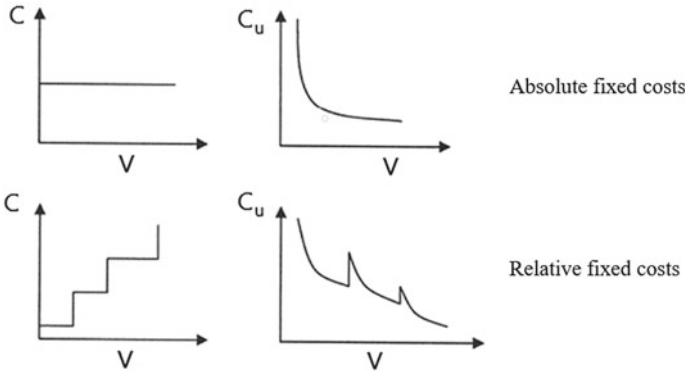


Fig. 5 Absolute and relative fixes costs [13]

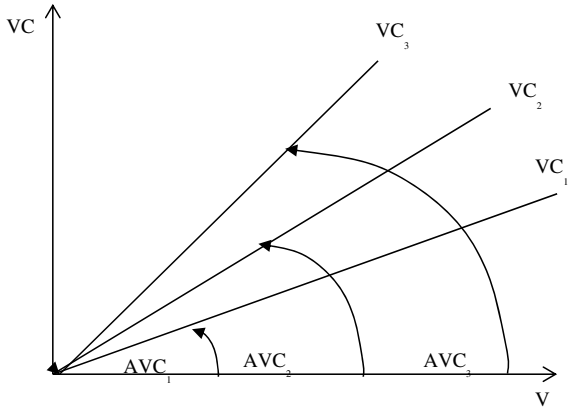


Fig. 6 Proportional variable costs [13]

They are divided into the following:

- *Proportional*: depending on the production, they progress in the same proportion as production. They increase as the production increases, that is, when production increases, so does the increase in costs, in the same ratio (cost function has the shape of a line). We can draw it as in Fig. 6.
- *Proportional*: depending on the production, they progress in the same proportion as production. They increase as the production increases, that is, when production increases, so does the increase in costs, in the same ratio (cost function has the shape of a line). Proportional costs are, for example, material consumption, production workers salaries, and so on. We can draw it as in Fig. 6.
- *Non-proportional costs*:

  Progressive (over-proportional): They increase in a greater manner as performance increases, with decreasing production volumes, their amounts decrease less significantly. They are related to unplanned activities of the company, e.g., night work allowances, overtime pay, costs used for repairs, spare parts for the repairs of old machines, etc.,
  Degressive (under-proportional): They increase in smaller manner as production volumes, e.g., repairing costs for long-term tangible assets, technological fuel costs, salary costs for administration staff,
  Regressive: They progress inversely with volume production, so their total amount decreases with increasing performance volumes and increases with decreasing performance volumes. For example, wages paid for downtimes, waiting times, etc.

They can be expressed as in the following Fig. 7.

The cost development is affected by changes in the conditions of the company's activities. That means that due to changes in performance volumes, price changes of used material, technology, work organisation and other factors, proportional costs

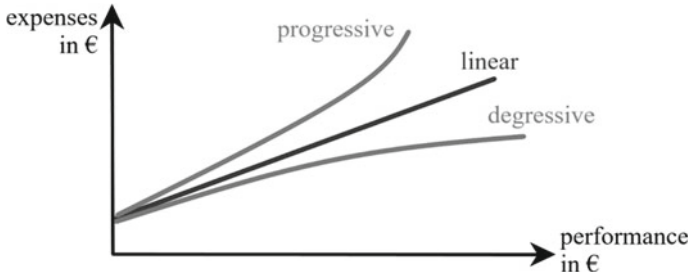


Fig. 7 Non-proportional variable costs [13]

could possibly change to degressive, degressive to progressive, etc. This is called flexibility, i.e., cost flexibility.

If we depict various types of costs into one group and graphically represent the dependability of performance volumes and amounts of each type of costs, curves with typical course emerge (Fig. 8). Total costs are represented by the sum of all fixed and variable parts of the costs.

Each type of variable and fixed costs does not exist in the company separately. They always appear as mixed costs, i.e., they contain part of absolute fixed costs—permanent ones and relatively fixed costs—gradual ones, as well as all other types of variable costs. That causes that graphic depiction of total costs, respectively, whole course of the curve is not linear. Its shape is therefore dependent on specific conditions, but it is generally represented by an S curve. The graphical overview of total costs is shown in Fig. 8.

Analysis of the Break-even Point. The break-even point is the number of units that must be sold in order to produce a profit of zero and cover all the costs (variable + fixed). In this amount of production, the total revenues are equal to the total costs. Variable costs and total costs are related to the amount of services sold. The difference

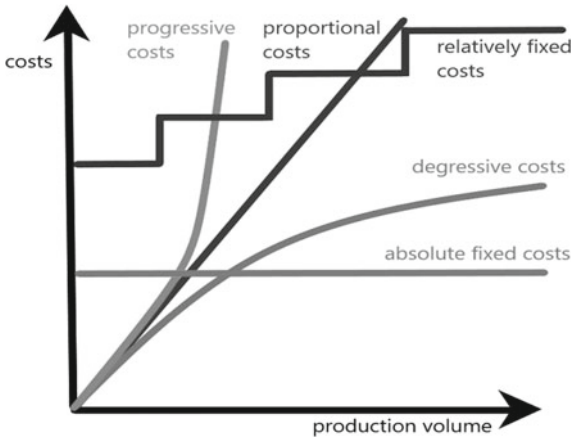


Fig. 8 Graphical overview of total costs [13]

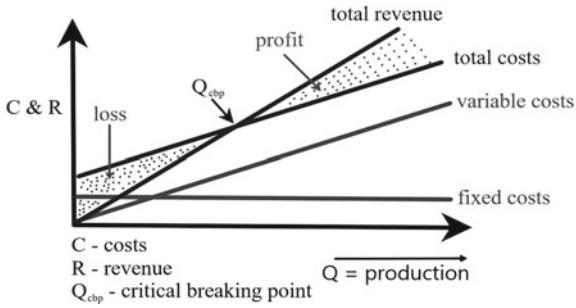


Fig. 9 Graphical representation of the break-even point

between the price and variable costs is called the contribution for fixed costs covering and profit generation. The break-even point can be expressed as a formula:

$$\text{Qbp} = \frac{\text{Fixed Costs(FC)}}{\text{Price per Unit(P)} - \text{Variable Costs per Unit}(V_C)} \tag{13}$$

Production volume below the break-even point gets the company into the loss and production volume above the break-even point brings the company profit. This can be seen in Fig. 9:

Calculation Breakdown of Costs. For cost monitoring in the calculation breakdown, it is characteristic that the total costs are divided into two large groups:

- *Direct costs*—emerge in direct connection with particular performance. They apply directly to the calculation unit. They are determined by an exact detection of their actual volume or consumption standards.
- *Indirect costs*—emerge as a result of the joint provision of a service and production management, these are overhead costs. They are mutual for all duties, e.g., building regulations, director's salary, advertising, …

They are calculated per calculation unit by scheduling based on a specific calculation method. The procedure to allocate overhead costs to a calculation unit is called a method of calculation (calculation method).

We distinguish:

1. Division calculation:
   a. Basic division calculation,
   b. Division calculation by ratio numbers.
2. Mark-up calculation,
3. Combined output calculation.

Basic Division Calculation. Is used when the company produces one performance (one product) only. In that case, the costs of a calculation unit are calculated as the ratio of the company's costs in the defined period and the number of performances.

If production is simply structured, this calculation by division represents a simple and sufficient form of determining the own costs. It can also be assumed that the

company does not store its products and so there is no need to record a change in stocks [14].

Division Calculation by Ratio Numbers. Is used when the company produces more types of products produced by the same technological process, but differentiated in higher direct material usage, labor, etc.

The procedure for compiling a calculation with ratio numbers includes the following steps:

1. Of all the performances, one is chosen as the basic one (it is produced the most or has a higher workload), and a ratio number of 1 is determined for it,
2. All other outputs are converted to this basic output using ratios,
3. Overhead costs are divided by recalculated power,
4. The ratio recalculates the costs for individual types of output (the value of the output must be recalculated by the ratio).

Mark-up Calculation. Is used when the company produces more types of product differentiated in material consumption, labor, etc.

Indirect costs for several types of output are determined in a calculation using an *overhead surcharge* or *overhead rate* (depending on the scheduling (distribution) base used).

The overhead surcharge expresses the percentage of overhead costs that are passed on to each type of performance according to the chosen base.

$$\%\text{Overhead surplus} = \frac{\text{Volume of the layout cost}}{\text{Distribution base in units}} * 100 \tag{14}$$

The distribution base must be determined so that the overhead costs are very closely related to it (as the base increases, the overhead costs for the calculated unit increase and vice versa). In practice, direct wages are used most often as a distribution basis.

Calculation Formula. The calculation formula represents the loading order of the individual calculation items. Companies can create calculation formulas as needed. The calculation formula applied in agriculture has its specifics, which result from the peculiarities of plant and animal production.

The calculation formula contains the following elements:

- Direct material,
- Direct wages,
- Other direct costs,
- Production overhead,
- Administrative overhead,
- Sales overhead.

This calculation formula combines the direct costs that we can calculate per specific unit and then adds indirect costs to the calculation in the form of overheads. These overheads indirectly contribute to the creation of the product, but without them

the product would not be complete, for example, without marketing we would not sell the products, without logistics we would not distribute them, etc.

Cost characteristics depending on the user information:

1. *Costs depicted in the financial accounting*: owners, shareholders, and employees understand costs as the withdrawal (reduction) of equity, which is depicted in the financial accounting. The mutual characteristics of the costs depicted in financial accounting are the reduction in assets, not the purpose.
2. *Costs in terms of tax*: the state intervenes and indirectly regulates the mentioned losses of assets (costs) and divides them into two groups, namely costs that were not necessary (e.g., gifts, refreshments, fines, etc.) and costs that are necessary to achieve, ensure, and maintain the incomes.
3. *Costs shown in the company's internal accounting*: The content of internal (also referred to as cost) accounting are the costs as purposeful and specific expenditures of resources used for economic growth of the company. Efficiency is given by the fact that the basis is considered to be an adequate expenditure of resources, and this is to some extent quantified by the degree of efficiency. Purposefulness expresses the fact that the purpose of the spent economic resource is its evaluation.

4 Investment Evaluation

Financial analysis represents an important source of information necessary for decision-making regarding the formation of the capital structure of the company. The capital structure has an impact on three essential goals, which are prerequisites for maintaining the financial balance, namely profitability, liquidity, and stability. A particular balance among these three goals is needed; therefore, it is not possible to maximize the fulfilment of all at once. The profitability of the company's own capital and other profitability indicators depend directly on the share and structure of external resources and the related obligations of the company to pay interest. Short-term external resources (borrowings) represent input data in the calculation of liquidity ratios that they characterise.

Financial analysis is understood as retrospective and perspective, while current state is examined and analysed by the glance into the past. We are trying to find out how and by what means have decisions from the past affected the current state of the company. However, this state cannot be changed. On the other hand, perspective analysis is trying to foresee the development of financial situation with the help of selected financial indicators and take well-timed measures in order to prevent financial crisis of the company. This method of financial analysis is based on the cognition that selected financial indicators can draw attention to imminent financial problems in the future at a very early period.

A company is financially sound when it has no problems with the ability to pay its debts on time [15].

If a company is sound and thrives long-term, it is necessary to keep in mind its long-term future, so it deals with investments in its future and developing better

market position. Investments are considered as the most important factor of economic development of a company, by which perspective state policy is implemented, its particular areas, and every company. In the following pages, we will explain the essence of investments, their structure, and their distribution.

4.1 Basic Investment Understanding

Investment is an asset that a company owns to increase its fortune in all these assets, such as interest, dividend, royalties, and rent, to capitalize the asset, or to obtain other benefits for the investment firm from the holding of the asset [16].

From a macroeconomic point of view, investments are considered as postponing the part of consumption that will bring us the desired effect in the future.

Investments in macroeconomy have two roles:

1. They are a huge and unstable part of the expenses, mostly unexpected swift changes in the investments can have considerable influence over aggregate demand, which naturally affects employment.
2. Investments lead to capital accumulation, to the increase in fixed capital, which positively affects the potential growth of the country. Therefore, long-term economic growth is stimulated.

From the company's point of view, investments are understood as assets, which are not determined for immediate use, but for asset production in the future period. They are also understood as one-time capital costs, which represent financial flows over a long-term period. Every business entity must decide when is the right time to invest and what it will bring in the future. We must evaluate its benefits, which we compare with given capital costs and with the importance of the company on the market.

4.2 Structure and Investment Classification

When we talk about investments, we encounter their essential part, which is investing and investment decision making. Investing or investment is nowadays a common way of achieving profits through passive use of its own financial resources. At the same time, these are long-term monetary operations, which we distinguish according to what they are aimed at, for example focus on asset-making, costs, right of disposal, or future profit [17].

Investment decision making cannot be separated from the capital market. It represents a use of financial resources (capital expenditures) in order to acquire fixed assets of the company. It is one of the crucial decisions of the company, because it determines the future operation of the company. Investment decision making is part of financial decision making [18].

Investing is a long-term commitment of capital (use of financial resources to make a profit. Investments are divided according to the future benefit and their use.

Investments are divided according to the following:

1. *Their specialisation*:
   a. *Production*, in the case they are directed into product-manufacturing industries or services intended for sale (industry, construction, agriculture, forestry, transport, etc.),
   b. *Non-productive*, in the case they are directed into non-productive sphere; they serve social and individual consumption directly; most of the services are not saleable and are financed mostly from national budget (education, healthcare, state service, etc.).
2. *The Nature of Constant Capital Reproduction*:
   a. *Renewable*, which replaces wear of constant capital, i.e., a volume of capital in operation does not change, only its factual form. The implementation of renewal investments assumes a decrease in given production and the elimination of a certain workforce. On the other hand, it means an increase in the same physical volume of fixed capital, as a result of technical progress,
   b. *Progressive*, which expand capital volume in companies and whole economy, its source is accumulation. It is known that the greatest production growth and therefore the greatest possible economic growth would be achieved when the whole disposable investment volume was used for development investments. However, such use is limited, at least by the physical wear and tear of capital, as well as by sources of skilled manpower.
3. *Their internal composition*:
   a. *Building (passive)*, which creates conditions for the own manufacturing process, resp. the process of provided services,
   b. *Machine-technological (active)*, which allows for increasing the efficiency of the production process.
4. *The ownership of investors*:
   a. Private sector investment,
   b. Investments in the public sector,
   c. Investments in the cooperative sector,
   d. Investment by the population.
5. *From an accounting point of view*, three basic groups of investments are distinguished [19]
   a. *Financial*—purchase of long-term securities, deposits in investment companies, long-term loans, etc.
   b. *Tangible*—construction of new production capacities of the company, acquisition of land and buildings, purchase of production equipment, machinery, means of transport, etc.

c. *Intangible*—purchase of know—how, licenses, software, research expenditure, education, etc.

6. *From a macroeconomic point of view*, we distinguish:

   a. Gross investment is defined as the increase in capital goods, i.e. buildings, halls of machinery and equipment, vehicles, supplies, etc. for a given period. They are the result of a choice between the production of consumer goods and the production of capital goods. If we sacrifice part of the consumption, i.e. we prefer the production of capital goods, we can expect a faster development of the economy—in the future our gross national product will grow,
   b. We define net investment as the difference between gross investment and capital impairment (especially depreciation). The following interrelationships apply; gross investment > capital impairment > net investment.

4.3 Economic Functions of Investments

According to Polách [20], investments fulfil three relatively independent functions in the economy:

- Capacitive,
- Cost,
- Pension.

The capacitive function is expressed by new estates, which are formed by investments, create new manufacturing capacities and non-productive sectors of national economy. New capacities do not necessarily mean expansion, but also replacement of existing capacities by recovery. If they exceed the level of realised recovery, they represent expansion. The capacitive function is mainly related to external economic development and positively affects the growth of added value.

The cost (substitutional) function adds and partially modifies the capacitive function. The essence of the substitution function lies in the fact that there is a certain possibility of interchangeability between individual factors of production, substitution of one factor by another, i.e. their mutual substitution. However, this substitution is always only partial and limited. As a result of scientific and technical development, the rate of substitution of each factor is constantly increasing.

Substitutional investments ensure an increase in production effectiveness by cost reduction. We differentiate three basic types of substitutional investments:

- Investments in the replacement of raw materials, materials, fuels, and energy,
- Investments in the replacement of constant capital elements,
- Investments in the placement of labour by constant capital.

The pension function is shown in the phase of investment realisation, that is, in the time when investments do not contribute to the product production. Investments in cash are a specific form of investments and supply requirements for investors. Part of

the population's pensions also arise in investment construction. These are pensions of employees of investment sectors, which are used as a demand for consumer goods and paid services. The pension function basically creates a certain tendency to increase demand in the economy. A high volume of investment and prolonging the period of construction lead to mortification, respectively, blocking of funds in capital construction, which has a negative impact on demand in the economy. Excess demand creates an imbalance of supply and demand and thus generally inflationary pressure.

Division of Investments. The investment in the broadest sense means sacrificing some of today's value in order to gain some future value. Important factors that affect the investment process are risk and time. The present values are secured, while future rewards are uncertain. On the contrary, in this case, it is not guaranteed whether it will be received at all and, if so, it is not known with certainty to what extent.

Real investments are represented by materialized files (buildings, land, machines) but also intangible files (patents, licenses, knowledge). This group represents some transition between real and financial investments, given their liquidity. Investments in gold and silver coins or medals that have art or collectible value are gaining popularity recently. They also serve as a value-keepers thanks to the guaranteed amount of gold and the nominal value guaranteed by sign banks as their usual issuers. Coins are among the most popular tools for small investors. Their popularity is mainly evidenced by their high production, low production costs, and acceptable profit [21].

Financial investments means the purchase of "paper" or "computer" claims. Financial investment by a depositary, contractual or investment intermediary is usually recorded in the form of an entry into the passbook or an entry into an account managed by savers, investors, or by receiving a security in a materialized form. However, not every investment is equally profitable, safe, and therefore repayable. For this reason, the risk arising from different types of financial investments should also be spread over several sectors as well. This way of selecting investment entities is called portfolio creation. A financial investment is usually a certificate or an entry in a registered document and represents a financial asset [20].

4.4 Methods of Investment Evaluations

It is necessary to find out what time is needed for the invested funds to return, what their evaluation will be, and what other profits can be expected in the future from the implementation of the project under the given market conditions. In essence, the evaluation of projects is an assessment of their effectiveness, economy, and feasibility [19].

Various investment evaluation methods are used to assess the implementation of an investment. We can divide them from different points of view. Depending on whether the methods consider the time factor, we recognize the following methods [22]:

1. *Static*—do not take time into account,
2. *Dynamic*—consider the time factor.

Static Methods are used when the time factor does not have a significant effect on investment decisions. Abstracting from the time factor is not entirely correct, but usually does not have a significant effect on the evaluation and selection of the relevant variant. The amount of the discount rate (or the required rate of return) also plays an important role here. The lower the influence, the less significant the influence of the time factor [23].

Methods that pay for effective investments designed to reduce costs are important. These methods can be used in case we decide on variants that ensure the same volume of production, used to project evaluation for which we cannot estimate the prices of products that will be invested in production, using these methods, we cannot express project efficiency, we can only determine which project is more cost-saving.

Average annual cost method. Average annual costs are based on the costs incurred when investing. They take into account indicators such as depreciation, interest, investment costs, and other economic costs. Depreciation is part of economic costs. The investment cost represents the arranged cost of the investment. Other economic costs are calculated as the difference between total and economic costs and depreciation. The indicator is expressed in euros [22].

$$\begin{aligned}\text{Average annual costs} = {} & \text{Depreciation} + \text{Interest investment costs} \\ & + \text{Other annual economic costs}\end{aligned} \tag{15}$$

If we consider that the investment will be sold at the end of its useful life, then the formula for the liquidation price of the investment must be adjusted.

$$\begin{aligned}&\text{Average annual costs at the end of lifespan of the investment} = \\ &\quad \text{Depreciation} + \text{Interest investment costs} + \text{Other annual economic cost} \\ &\quad - \text{Liquidation price/Lifetime of the investment}\end{aligned} \tag{16}$$

Dynamic Methods are more often used in the process of selecting and evaluating investment. As practical experience shows, these methods are difficult to understand by ordinary managers and sometimes require complex computations. Dynamic methods use in the assessment of investment the size of the investment, expected revenues, and expenses during investment life. They use *discounting* for the purpose of considering the time factor. Discounting allows for standardization and allows a comparison of both inputs and outcomes, which are implemented in different periods of time [24].

$$\text{DiscountFactor}: \frac{1}{(1 + \text{Discount Rate})^{\text{Number of Periods}}} = \frac{1}{(1 + \mathrm{i})^{\mathrm{t}}} \tag{17}$$

Method of discounted costs. When calculating this criterion, all costs, both investment and operating, are calculated over the life of the project.

Calculation of discounted costs can be depicted as:

$$\text{Discount Costs (DC)} = \text{CE} + \text{DOC} = \text{CE} + \sum_{t=1}^{n} \frac{\text{OC}}{(1+i)^t} \tag{18}$$

where: CE are Capital Expenditure,

DOC are Discounted Annual Operating Costs without Depreciation,

OC are Operating Costs without Depreciation,

i is Required Rate of Return,

t are Individual Years of the Investment Life.

Discounted costs of investments can be characterised as an amount of money, which the company would postpone at the moment of commissioning in order to secure a procurement and operation of proposed investment.

When using the discounted cost method to select from variants with different lifetimes, both variants must be converted to a common lifespan. This is the smallest common multiple of the service life of the individual variants being compared. In the case of the variant with a shorter service life, the current value of the renewed assets must also be taken into account.

Net present value. The net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyze the profitability of a projected investment or project.

The following formula is used to calculate NPV:

$$\text{NPV} = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t} = \sum_{t=1}^{n} \frac{CF_t}{(1+i)^t} - \sum_{t=1}^{n} \frac{IC_t}{(1+i)^t} \tag{19}$$

where: R_t are Net Cash Inflows − Outflows During a Single Period,

CF_t is Cash Flow from the Investment in the year t,

IC_t is Invested Cash in the year t,

i is Required Rate of Return (Discount Rate),

t are Individual years of the Investment Life,

n is Total Lifespan of the Investment.

A positive net present value indicates that the projected earnings generated by a project or investment, in present value, exceed the anticipated costs, also in present value. It is assumed that an investment with a positive NPV will be profitable, and an investment with a negative NPV will result in a net loss. This concept is the basis for the Net Present Value Rule, which dictates that only investments with positive NPV values should be considered. NPV is very sensitive to the discount rate. As a discount rate, the opportunity cost, the price of money in the capital market, the risk-free investment rate, or the return on equity can usually be chosen.

Internal return rate. The internal return rate is a metric used in financial analysis to estimate the profitability of potential investments. The internal return rate is a discount rate that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis. The IRR calculations are based on the same formula as the NPV calculations.

The formula and calculation used to determine this figure are as follows:

$$\text{IRR} \rightarrow \ \text{NPV} = \sum_{i=1}^{T} \frac{C_t}{(1+\text{IRR})^t} - C = 0 \tag{20}$$

where: $C_t$is Net Cash Inflow during the Period t,

C are Total Initial Investment Costs,

IRR is the Internal Rate of Return,

t are the numbers of time periods.

To calculate the IRR using this formula, one would set the NPV equal to zero and solve the discount rate, which is the IRR. However, because of the nature of the formula, IRR cannot be easily calculated analytically and therefore must instead be calculated through trial and error or by using software programmed to calculate IRR. This can be done in Excel.

The higher an internal rate of return, the more desirable an investment is to undertake. The IRR is uniform for investments of varying types, and, as such, the IRR can be used to rank multiple prospective investments or projects on a relatively even basis. In general, when comparing investment options whose different characteristics are similar, the investment with the highest IRR would probably be considered the best.

Payback period. The payback period (PBP) refers to the amount of time it takes to recover the cost of an investment. Simply put, the payback period is the amount of time that an investment reaches a break-even point. The desirability of an investment is directly related to its payback period. Shorter paybacks mean more attractive investments.

Although calculating the payback period is useful in financial and capital budgeting, this metric also has applications in other industries. It can be used by homeowners and businesses to calculate the return on energy-efficient technologies such as solar panels and insulation, including maintenance and upgrades.

Corporate finance is all about capital budgeting. One of the most important concepts that every corporate financial analyst must learn is how to value different investments or operational projects to determine the most profitable project or investment to undertake. One-way corporate financial analysts do this is with the payback period.

The payback period is the cost of an investment divided by the annual cash flow. The shorter the payback, the more desirable the investment.

$$\text{PBP} = \frac{\text{Initial Investment}}{\text{Cash Flow per Year}} = \frac{C}{\sum_{t=1}^{n} \frac{CF_t}{(1+i)^t}} \tag{21}$$

Capital Budgeting and the Payback Period. Unfortunately, there is one problem with the payback period calculation: Unlike other methods of capital budgeting, the payback period ignores the time value of money (TVM)—the idea that money today is worth more than the same amount in the future because of the earning potential of the present money.

Most capital budgeting formulas, such as net present value (NPV), internal rate of return (IRR), and discounted cash flow, consider the TVM. So if you pay an investor tomorrow, it must include an opportunity cost. The TVM is a concept that assigns a value to this opportunity cost.

The payback period disregards the value of money in time. It is determined by counting the number of years it takes to recover the funds invested. For example, if it takes five years to recover the cost of an investment, the payback period is five years. Some analysts favour the payback method for its simplicity. Others like to use it as an additional point of reference in a capital budgeting decision framework.

The payback period does not account for what happens after the payback, ignoring the overall profitability of an investment. Therefore, many managers and investors prefer to use NPV as a tool to make investment decisions. The NPV is the difference between the present value of cash coming in and the current value of cash going out over a period of time.

These methods are among the classics in terms of investment evaluation. For each investment, its return is important and is assessed separately. Risk analysis is an important factor in any investment.

4.5 Risk Analysis

In addition to the analysis of investment efficiency, the risk analysis has an application. Usually, project variants with higher efficiency are riskier, and vice versa. With short-term investments, the probability of repayment is high. The investor is looking for the optimal variant that is effective for the company with an acceptable level of risk.

Long-term investment projects are capital intensive, their risk grows and is bound to the external factors (economy and market development, inflation, interest rate).

There is a huge amount of risk affecting investment projects. The most significant are [25]:

- *Commercial risk*—related to the quality of management, the reality of conversions and the estimation of the future, but also to the progress of competing companies that is difficult to predict. All these effects can define corporate income either positively or negatively,
- *Financial risk*—affected by changes in interest rates, loan conditions, guarantees, etc.

- *Technical risk*—associated with the operation of the equipment, its moral obsolescence, and other facts that may change the operating costs compared to the planned condition.

The source of uncertainty and possible deviations from the expected and actual achievements of the project may include the following factors:

- Underestimation of fixed investment costs and working capital,
- Failure to reach production capacity,
- Technological and equipment changes,
- Changes in demand,
- Changes in the sales prices of manufactured products and changes in the prices of individual inputs,
- Macroeconomic changes in economic policy,
- Changes in the international economic and political environment.

Business risk is also expressed as a probability to achieve different results from the anticipated, both favorable and unfavourable results compared to the projected development. The probability of an individual monetary income or investment expense can be determined as a percentage of the probability of its occurrence. Based on the delimitation of a particular cash flow variant of certain probability levels, the so-called average expected value of cash flows is determined. However, this does not determine the risk of a particular investment project. The same expected average cash flows can be linked to risk.

The amount of risk taken is related to the amount of return that we want to achieve for the risk taken. We know three basic terms within the investment that are closely related, namely risk, yield, and liquidity. These are depicted in a magical triangle in Fig. 10.

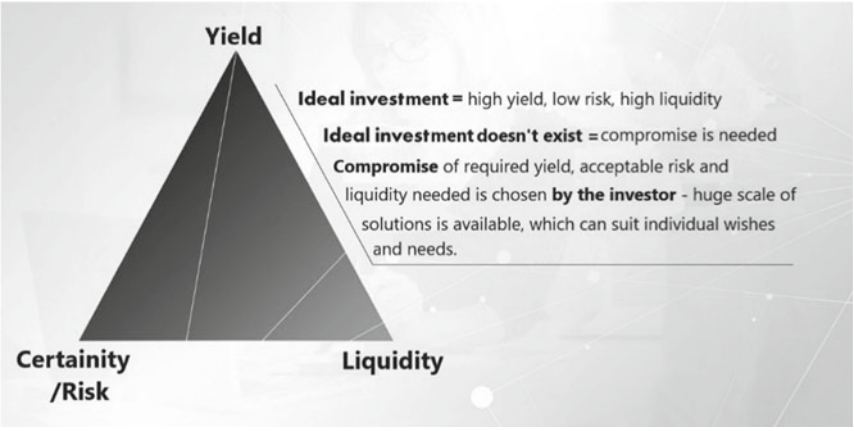


Fig. 10 Magical triangle of investment

There is risk, yield, and liquidity associated with each investment, which form a magic (investment) triangle. It shows that with increasing yield, the risk increases, and the liquidity (availability of money) gradually decreases. The most liquid is money, and less liquid assets include real estate (buying and selling is calculated in weeks). The yield can take the form of a contract (bank deposits, bonds) or as a share of success (shares). In general, the higher the potential for profit, the higher the fees associated with the product.

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References

1. Wagner, J.: Merení výkonnosti: jak merit, vyhodnocovat a využívat informace o podnikové výkonnosti. Grada, Praha (2009)
2. Neumaierová, I., Neumaier, I.: Výkonnost a tržní hodnota firmy. Grada, Praha (2002)
3. Slávik, Š.: Strategický manažment. Sprint 2, Bratislava (2013)
4. Poniszewska-Maranda, D., Matusiak, R., Kryvinska, N., Yasar, A.-U.-H.: A real-time service system in the cloud. J. Ambient Intell. Human Comput. **11**(3), 961–977 (2020). https://doi.org/10.1007/s12652-019-01203-7
5. Poniszewska-Maranda, A., Kaczmarek, D., Kryvinska, N., Xhafa, F.: Studying usability of AI in the IoT systems/paradigm through embedding NN techniques into mobile smart service system. Computing **101**(11), 1661–1685 (2019). https://doi.org/10.1007/s00607-018-0680-z
6. What are the best ways to express measures using two or more variables? | Iowa Department of Management. https://dom.iowa.gov/faq/what-are-best-ways-express-measures-using-two-or-more-variables
7. Amirbekuly, Y., Ukubasova, G.S., Kaskin, T.T.: Factors of competitiveness of the enterprise. The complicated processes of reforming economic relations and the development. Bulletin of the Karagand University (2017)
8. Centre for International Competitiveness, http://cforic.org/
9. Bondareva, I., Zatrochová, M.: Podnikové financie. Teória a praktické aspekty riadenia. SPEKTRUM STU, Bratislava (2017)
10. Kraľovič, J., Vlachynský, K.: Finančný manažment. Iura Edition, Bratislava (2011)
11. Schroll, R.: Kontrola nákladov a kalkulácie v priemysle. Slov. ped. nakl., Bratislava (1992)
12. Kajanová, J.: Costs under the pressure of globalization. (2017)
13. Majerník, M., Zatrochová, M., Kuperová, M., Majerník, Š.: Rozpočtovníctvo. Náklady a ceny. STATIS, Braitslava (2017)
14. Tóth, M., Šagátová, S.: Nákladový controlling. Wolters Kluwer (2020)
15. Šlosárová, A., Blahušiaková, M.: Analýza účtovnej závierky. Wolters Kluwer, Bratislava (2017)
16. Kovanicová, D.: Finanční účetnictví: svetový koncept. Polygon, Praha (2003)
17. Bondareva, I., Katrenčík, I., Zatrochová, M.: Finančný trh. Teória a prax. SPEKTRUM STU (2021)
18. Brealey, R.A., Myers, S.C., Melnycok, J., Tuma, M., Tuma, Z.: Teorie a praxe firemních financí. Victoria Publishing, Praha (1992)
19. Kislingerová, E.: Manažerské finance. C.H. Beck, Praha (2007)
20. Polách, J. (ed.): Reálné a finanční investice. C.H. Beck, V Praze (2012)

21. Drábek, J., Polách, J.: Reálne a finančné investovanie firiem. Technická univerzita vo Zvolene, Zvolen (2008)
22. Miklovičová, J.: Ekonomika investičných projektov. Vydavateľstvo SPU, Nitra (2012)
23. Hrdý, M.: Hodnocení ekonomické efektivnosti investičních projektů EU. Wolters Kluwer (2006)
24. Szymszal, J., Lis, T., Gajdzik, B., Kliś, J.: Analysis of the possibility of using dynamic methods for assessment of investment projects in the domestic foundry industry. Arch. Foundry Eng. (2014). https://doi.org/10.2478/afe-2014-0071
25. Čunderlík, D., Rybárová, D.: Podnikateľské riziko. Ekonóm, Bratislava (2002)

Organization and Financing of Healthcare in the Slovak Republic and Selected European Countries

Stanislav Filip, Nadiya Dubrovina, and Mykola Sidak

Abstract This article was written to serve as source material for international research of Health Profiles of Countries, legislative frameworks, organizational structures and systems of financing in health care in the Slovak Republic and other European countries, including new members of the EU, to create an information database for students, teachers and researchers for further education and research on a given issue at national and international level. The article gives an overview of the latest research papers in registered databases, creates the legislative framework of healthcare provision, presents the current state of the healthcare system in the Slovak Republic, and illustrates the starting point of the approved healthcare reform strategy with an emphasis on the powers assigned to public administration bodies. It analyzes the state and development of healthcare financing in the Slovak Republic as well as the improvement of selected indicators of the country's health profile for the years 2017 to 2021. This paper aims to establish a database of baseline data for quantitative analysis and qualitative review of the efficiency, trends and challenges of the organisation and financing schemes in selected European health systems. It aims to identify and provide a cross-country difference assessment based on result comparison and suggest feasible optimising solutions. The joint monograph as a research output will reflect on the Country Health Profile of Slovakia and other European countries, organisational and financing changes in healthcare.

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1 Introduction

The Slovak healthcare system is based on the principles of universal accessibility, compulsory levy health insurance and a standard healthcare provision covered by the public insurance program.

Since the establishment of the Slovak Republik, the Slovak healthcare system, its legislative framework, organisational structure, as well as financing scheme have undergone several changes introduced by the political parties in power. The efficiency of the healthcare system has resulted in an improvement of the general health status of citizens over the last 15 years. However, the mayor part of public health status indicators remains lower than the EU average. Life expectancy in Slovakia ranks one of the lowest in Europe, even recording a drop by one year in 2020 due to the COVID-19 pandemic. According to the Slovak Statistical Office, over 73,000 people died in 2021, breaking the 20-year-old record.

One of the long-standing problems of the Slovak healthcare system is the fiscal sustainability and cost-efficiency due to low health expenditure, which significantly contributed to the poor healthcare services performance during the global pandemic COVID-19.

School of Economics and Management in Public Administration offers a variety of study programmes and even a bachelor's study programme in Economy and Management of Public Services with a focus on health and social services. To support and expand study materials for students and teachers, the authors of the article, with the financial support of the Grant Agency of the School of Economics and Management in Public Administration, have prepared and are currently implementing an international research project named Improving the Efficiency of Healthcare, New Trends and Challenges. The project aims to investigate typological problems of legislative frameworks, organization and funding of healthcare systems within the selected European countries and to create the complex of recommendations for national healthcare systems, including Ukraine.

Monograph as project output will consist of analysis, assessments and comparison of particular systems and it will outline possible healthcare system efficiency improvements.

2 Literature Review

The literature review lists scientific papers and publications by Slovak and foreign authors, as well as annual reports and statistical data on the researched issue.

Szalay et al. [1], Zachar [2] and also Sreablová [3] discuss healthcare organizational structure, legal framework, terminology, as well as a transformation of financing schemes and examine healthcare system efficiency. An international team of authors led by Samtana et al. [4] provides a comprehensive look at the organization and management, financing, material human resources, and services provided as

well as a description of major reforms and evaluation of the healthcare system in the Slovak Republic. A Paper titled *Healthcare, Markets, Regulation and Politics* written by a team of authors led by Morvay [5] deals with the issue of healthcare financing and its mechanisms. The chapter on financing answers the key questions Who is funding health services? How are these funds allocated to health service providers? Which is the most efficient way to avoid a healthcare system underfunding. The authors of this part of the given paper Kováč [6] analyse the impact of the quality of a healthcare system on the safety of citizens using the latest methods and measurements of the safety. A similar problem of the impact of healthcare systems as one of the key general public safety factors of several countries of the world has been studied by Kabat et al. [7].

Gavurová [8] discusses the issue of long-term health care in *Slovakia and the analysis of its potential and structural determinants.* Gavurová et al. [9] examine and present the issues of efficiency of the Slovak healthcare system. A specific area of the pharmacy market analysis in Slovakia and the Czech Republic is presented by the international team of authors Szalayová et al. [10].

The issue of healthcare efficiency and value improvement has been studied and published by Fraser et al. [11].

Plenty further information on the Slovak medical organizational structure and its impact on the health of the population can be found in a number of annual reports and statistical data published on the official websites of the Ministry of Health of the Slovak Republic, the Public Health Authority and in the yearbooks of the Statistical Office of the Slovak Republic. Comparison of legislative changes and healthcare efficiency in the Slovak Republic with the European Union countries can also be made on the portals of Eurostat: Eurostat Health Database [12], OECD State of Health in the EU, Slovakia, Country Health Profile [13], HPI—Health Policy Institute [14].

The most recent articles registered in the SCOPUS and Web of Science databases focus on healthcare issues during a pandemic COVID-19. Perez et al. [15] analyse local government health funding in the United States during the COVID-19 pandemic. A special problem related to the restriction of re-export of selected pharmaceuticals and supervision of its compliance by public administrative authorities in the Slovak Republic is analyzed in their work by Peracek et al. [16]. Selected economic aspects of the availability of medicines in Slovakia are discussed in a publication by Meričková et al. [17].

State organization, health system model and health outcomes of COVID-19 in six European countries during the first months of the COVID-19 epidemic in 2020 reported by Simões et al. [18]. Identification and analysis of Structural Funds support to mitigate the effects of the COVID-19 pandemic in the EU in a case study of health facility financing is presented by Bedrunka et al. [19].

Integrated care and the 'agentification' of the English National Health Service are analysed by Wright and Turner [20]. Hahn et al. [21] report on the structure of ambulatory care: *Germany and other decentralized health care systems.*

3 Aim, Goals and Methodology

The authors' aim in publishing the article was to create a theoretical, methodological and statistical database that will serve as a basis for deeper joint research, comparison of legislative frameworks, organizational structure, financing schemes and health system efficiency assessment in the Slovak Republic and selected EU countries within the research project of the Grant Agency of VŠEM IGP M-02/2020 "*Improving healthcare efficiency: new trends and challenges*".

The authors of the article worked with an available database of local and foreign secondary sources and with primary sources obtained from their knowledge and experience of using healthcare services in Slovakia. Statistical data from the Statistical Yearbook of Slovakia 2020 published by the Statistical Office of the Slovak Republic, and annual reports of the Public Health Authority and the Ministry of Health of the Slovak Republic were used for analyses and comparisons.

The Slovak Health Profiles for 2017, 2019 and 2021, the outcome of joint activity of the OECD and the European Observatory on Health Systems and Policies in cooperation with the European Commission, were used to examine selected indicators of the health profile of the Slovak Republic. The online Eurostat Health Database served as an additional source of data applied in comparison of selected indicators of Slovakia and some neighbouring countries as well as with the EU average.

In addition to scientific abstraction and description, standard methods of scientific inquiry such as system analysis and synthesis were used in a process of article writing. Furthermore, the comparative method, descriptive statistics, multidimensional analysis, time series modelling, econometric models were employed. Methods of scientific induction and deduction were applied to evaluate the sub-analyses as well as to formulate conclusions and proposals.

4 Organizational Structure of the Slovak Health System

The organizational structure of the Slovak health system has been developing ever since the establishment of the Slovak Republic. Besides the introduction of the health insurance model itself, this period up to 2002 is characterised by the transformation of some health institutions from state-subsidized organisations to private entities.

The most significant transformation of the health system leading to its current form was carried out in the period of accession of the Slovak Republic to the EU and NATO in 2004. This period was marked by changes in the fiscal and tax area, in the pension system, the judiciary and the education system, in addition to the reform of the health system. This comprehensive reform was outlined by new legislation that restructured the health system. The reform included:

- The introduction of healthcare-related services and the ability to collect fees from.
- The adjustment of the contributions/levies paid by the state for economically inactive insured persons to reflect the average wage.

- A change in the redistribution of insurance premiums.
- Annual health insurance clearance.
- Liberalisation of the provider network (eligibility for authorisations and licences).
- Selective contracting.
- Independent supervision by the Health Care Surveillance Authority.
- Reform of the Emergency Medical Services.
- Transformation of all health insurance companies into joint stock companies.
- Transformation of some hospitals into joint stock companies.
- Creation of flexible instruments to define the extent of healthcare provision.

The current organisational structure of the Slovak health system is a result of the cooperation of the Ministry of Health, HICs, healthcare providers, professional organisations and the Health Care Surveillance Authority (UDZS). The state has remained the owner of the largest hospitals and the largest health insurance company.[1]

The state and state bodies play an integral role in the organisation and functioning of the Slovak health system. The scope and authority are defined by law.

- The National Council of the Slovak Republic—holds legislative and supervisory powers. It can conduct parliamentary inquiries in healthcare facilities and appoints and dismisses members of the Supervisory Board of the Health Care Surveillance Authority.
- Government of the Slovak Republic—approves the budgets of health insurers, prepares legislation amendments, and appoints the chairman of the Health Care Surveillance Authority (UDZS).
- The Ministry of Health of the Slovak Republic—is the central government body responsible for the development of health policy and legislation, the regulation of healthcare provision, and the management of state health programmes. It participates in the management of medical education and determines the extent of the standard healthcare provision covered by public insurance. Furthermore, Ministry of Health is the founder of university hospitals, teaching hospitals, specialised national institutes, sanatoriums and the largest health insurance company.
- The Ministries of Transport, Defence and the Interior are responsible for their health facilities, such as the Central Military Hospital in Ružomberok and the St. Michael's Hospital in Bratislava.
- Health Care Surveillance Authority (UDZS)—as an independent government body, monitor and conducts surveillance over healthcare provision, healthcare purchasing and supervision of health insurance companies. Moreover, it acts upon complaints from patients regarding the inadequate quality of healthcare provision and decides on the performing forensic and pathological-anatomical autopsies.[2]
- Public Health Authority (UVZ)—conducts public health-related activities. It is funded by the state budget. It is managed by the Chief Hygienist, appointed by the Minister of Health. Via its regional offices, it exercises epidemiological

[1] Szalay et al. [1, p. 8].

[2] Szalay et al. [1, p. 9].

surveillance, assesses health risks, issues business premises permits and monitors the quality of drinking and water in public pools.

- The State Institute for Drug Control (ŠUKL)—organisation funded by the state budget to conduct surveillance and control the safety of medicinal products and medical devices. It issues marketing authorization of medicinal products, ensures activities associated with the evaluation of pharmacies and manages the pharmacopoeia. It monitors and analyzes suspected adverse drug reactions, and is authorised to perform a withdrawal of medicinal products and medical devices. The Institute is also responsible for regulating the re-export of medicines.
- The Emergency Medical Services Operations Centre (OS ZZS)—a state-subsidized organization that manages all components of the emergency medical services. It consists of headquarters and eight regional operations centres integrated under one Integrated Rescue System. The operations centres issue instructions to ambulance services. 0.35% of overall health insurance levies collected by health insurance companies are allocated to finance the activities of the operational centres.
- National Health Information Center (NZIC)—a state-subsidized organization founded by the Ministry of Health. It performs activities associated with informatisation of the healthcare system (e-Health), standardisation of health IT, and health statistics. It operates national health registers. 0.41% of overall health insurance levies collected by health insurance companies are allocated to finance its activities.
- National Transfusion Service (NTS)—a state-subsidized organization, founded by the Ministry of Health of the Slovak Republic to provide complex and sustainable blood supply, and ensure the provision of haemotherapy. It consists of fourteen workplaces throughout Slovakia.
- National Transplant Organisation (NTO)—a state-subsidized organisation established by the Ministry of Health of the Slovak Republic to perform activities associated with the coordination of organ, tissue and cell procurement and transplantation. It leads the National Transplant Registry with waiting lists for transplantation and living donors registry.
- Tasks of health insurance companies—to administer purchases of health care services and to ensure healthcare provision to policyholders. All three health insurers—General Health Insurance Company, Dôvera and Union, are joint-stock companies and are therefore obliged to meet solvency criteria. The market shares of the insurance companies are shown in Table 1.
- The local government—have a regional authority to issue operational licences to healthcare facilities, appoint ethics committees, and approve biomedical research in outpatient clinics. They have adopted supervision over healthcare provision. If a healthcare facility fails to comply with assigned duties, local government bodies are entitled to impose financial sanctions or withdraw the operational permit of the healthcare facility but only upon the proposal of the Healthcare Surveillance Authority.
- Political parties, healthcare provider unions, and last but not least, even professional associations participate in the organisation and functioning of the health

Table 1 Number of policyholders in central registry of insured people to 1.1.202

Code of a health insurance company	Number of policyholders	% share of a health insurance company according to the overall number of policyholders
24_DÔVERA Insurance Company, JSC	1,651,152	31.93
25_General Health Insurance Company zdravotná poisťovňa, JSC	2,896,138	56.00
27_Union Insurance Company, JSC	624,384	12.07
Spolu	5,171,674	100.00

Source OZNAMENIE_podiel-PP_3.1.web_.pdf (udzs-sk.sk) [22]

system. Decisions are taken at all levels of government, from national to local governmental levels. Professional organisations promote the interests of their members vis-à-vis state authorities, self-governing regions and health insurance companies. They participate in the development of legal norms and educational programmes.

– Patient organisations represent members, usually disabled citizens. Association of Diabetics of Slovakia, the Slovak Association of Stoma patients, the League Against Cancer, and the League Against Rheumatism, lead the most active groups. The activities are focused on educating patients, their relatives and the public.

Overall view at the organizational structure of health system is provided in Fig. 1.

December 2021, the National Council of the Slovak Republic adopted the biggest public health reform since 2004, intending to ensure quality and accessible healthcare as well as provide doctors, nurses and other medical personnel with adequate working conditions. The reform aims to increase the number of hospital beds for secondary and long-term care and, at the same time, improve the quality of follow-up medical care as well as the care of chronically ill patients.

The reform optimises the network of acute care, emergency medical care as well as the provision of general care for adults, children and adolescents and others.

The reform calls for hospital network optimization at five levels, according to the type of health care, the distance from the patient's home and the time from diagnosis, the conditions and the quality of care. The design of the hospital network with the expected numbers, accessibility, hospital catchment area and % volume of healthcare is presented in Table 2.

The type and extent of healthcare provided at particular levels will be subject to reform. Extent shown in Table 3.

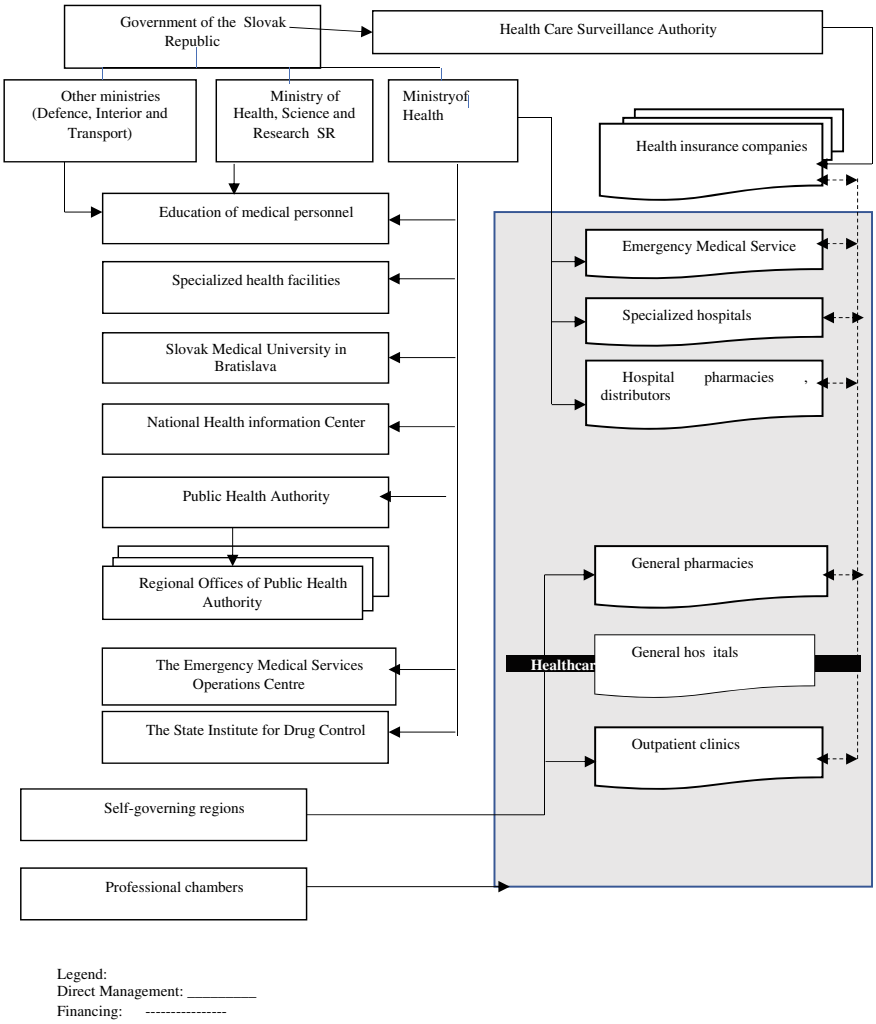

Fig. 1 Organizational structure of the Slovak health system 31. 12. 2016. *Source* Own elaboration according to Szalay a kol. 2011

5 Legal Framework

The constitution, so-called the Competence Act, specific laws and lower legal norms define the legal framework for Slovak healthcare.

Article 40 of Act No. 460/1992 Coll. of the Constitution of the Slovak Republic defines the fundamental right of citizens to health protection. It further establishes the

Table 2 Proposal of hospital network according to levels, accessibility and catchment area

Hospital level	Expected number	Accessibility	Catchment area	Share of health care
National level	1		The whole Slovakia	1 %
End level	3 – 4	• min 90% of citizens with 90 minutes long distance from nearest hospital • max 1,5 % citizens with 120 minutes long distance from nearest hospital	1,4 up to 2,0 mil. of citizens	8 %
Comprehensive level	8 - 10	• min 90% citizens with 60 mins long distance from the nearest hospital • max 1,5 % citizens in 90 minutes long distance from nearest hospital, • no region with average distance over 90 minutes to nearest hospital	450.000 up to 900.000 citizens	17 %
Regional level	28 - 32	• min 90% citizens with 30 minutes long distance from the nearest hospital • max 1,5 % citizens with 45 minutes long distance from the nearest hospital • no region with average accessibility of more than 45 minutes to the nearest hospital	100.000 up to 200.000 citizens, • even for 75.000 citizens if average distance in any region exesses min 35 • even less than 75.000 citizens in case an average distance for any region exesses 45.0000 • even more than 200.000 citizens in case it is higher level hostpital	75 %
Community level		• min 90% citizens with hospital accessiblity up 20 minutes, • max 1,5 % citizens with hospital accessibility up35 minutes, • žiaden okres nemá priemernú dostupnosť nad 35 minutes		

Source Own elaboration according to Ministry of Health of the Slovak. 2021 Press release. Available at Ministerstvo zdravotníctva Slovenskej republiky (gov.sk) [23]

right of citizens to free medical care and medical devices based on health insurance coverage under the conditions defined by the law.[3]

Act of the National Council of the Slovak Republic No. 575/2001 Coll. on the organisation of the government and the organisation of the state administration establishes the Ministry of Health as the central state administration authority for:

[3] Article 40 of Act No. 460/1992 Coll. Constitution of the Slovak Republic.

Table 3 Type and extent of healthcare provision at given levels

Hospital level	Definition of healthcare provided at a given level
National level	Highly specialised (quaternary) care with very rare occurrence
End level	Specialised (tertiary) care with low incidence
Comprehensive level	Comprehensive acute and planned care
Regional level	Standard acute and planned care at a regional level
Community level	Follow-up and rehabilitation care, emergency outpatient care, comprehensive outpatient specialised care, overnight healthcare, inpatient care, 8 - 10 hospitals also as comprehensive neuro-rehab centres, possibly for long term patients on ventilation, and three spinal centres for patients with paralysis.

Source Own elaboration according to Ministry of Health of the Slovak. 2021 Press release. Available at Ministerstvo zdravotníctva Slovenskej republiky (gov.sk) [24]

- healthcare,
- health protection,
- public health insurance,
- further education of medical personnel,
- thermal baths, natural medicinal sources, natural mineral waters,
- pricing policy on products, services and performances in the health sector and on the renting prices of non-residential premises in health facilities,
- control of biological weapons ban.[4]

Fundamental changes in legislation related to healthcare took place after the approximation of European law in 2004, when the basic laws were approved, introduced by the Constitution of the Slovak Republic. The harmonising set of legal norms that defined the health care system in the Slovak Republic includes six laws and their implementing regulations.

Act of the National Council of the Slovak Republic No. 576/2004 Coll. on health care, services related to the provision of healthcare and on amendment and supplementation of certain acts van be considered the most important law of mentioned above. This Act regulates the healthcare provision and provision of healthcare services, the rights and obligations of natural persons and legal entities in the provision of healthcare, procedures following death and state administration performance in the healthcare.

The second law is the Act of the National Council of the Slovak Republic No. 577/2004 Coll. on the extent of healthcare under public health insurance coverage and reimbursements of services related to healthcare provision. The purpose of this Act is to establish the extent of healthcare reimbursed from public health insurance coverage under the conditions determined by special regulations and reimbursement for services related to the provision of healthcare. Third Act of the National Council of the Slovak Republic No. 578/2004 Coll. on healthcare providers,…

[4] §19 of the Act of the National Council of the Slovak Republic No. 575/2001 Coll. on the Organisation of the Government and the Organisation of the Central State Administration.

medical personnel, professional associations in healthcare and on amendment and supplementation of certain acts. This Act stipulates:

- conditions for the provision of healthcare and health services,
- the conditions of the health profession performance, including the terms for the recognition of evidence in medical qualification in health-related professions,
- the education of medical professionals,
- the establishment, status, bodies and powers of professional associations in the health sector,
- the rights and obligations of a member of the chamber,
- the duties of the healthcare provider, and the healthcare worker,
- supervision of compliance with obligations and sanctions.

Act of the National Council of the Slovak Republic No. 579/2004 Coll. on Emergency Medical Services stipulates emergency medical care as defined by Act No. 576/2004 Coll.[5]

Act of the National Council of the Slovak Republic No. 580/2004 Coll. on Health Insurance stipulates health insurance, legal relations connected to health insurance and redistribution of public health insurance premiums.

Act of the National Council of the Slovak Republic No. 581/2004 Coll. on Health Insurance Companies, the Supervision of Health Care and Amendments and Additions to Certain Acts. This Act stipulates the status of health insurance companies, their activities, organisational structure and management, the establishment, scope and organisational structure of the Health Care Surveillance Authority and the nature of supervision. The hierarchy of these laws and the relations between them are shown in Fig. 2.

6 Financing Healthcare in SR and Other Selected Countries in Europe

As one of the important task is to provide the comparative analysis of financing healthcare in SR and other selected countries in Europe. The analysis of the tendencies in financing healthcare in SR on the background of the other countries in Europe, especially EU countries, allows to demonstrate essential changes in Slovakia and performance of the national reforms in the healthcare.

Over long run period, for example for EU-27 countries, the values of total government expenditure on health as % of total government expenditure were essentially increased, from 13.32% for EU-27 countries in 2000 till 15.35% in 2017. For EU-28 countries total government expenditure on health as % of total government expenditure increased from 13.4% in 2001 to 14.9% in 2017. In EU-19 (euro area) this indicator changed from 13.36% in 2000 to 15.5% in 2017 [25].

[5] § 2 (3) of Act No. 576/2004 Coll. on Healthcare, Services related to the Provision of Healthcare and on Amendment and Supplementation of Certain Acts.

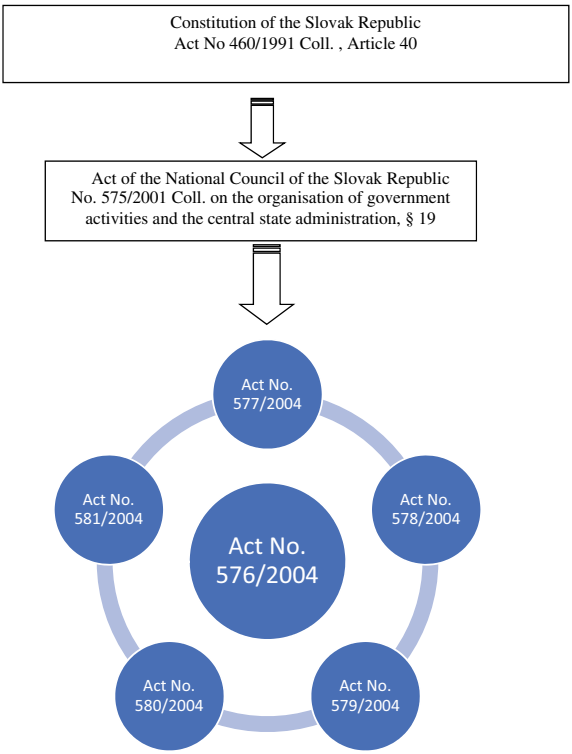

Fig. 2 Hierarchy of laws defining healthcare in the Slovak Republic. *Source* Own elaboration according to 10 years of Healthcare Reform

In 2017 the value of total government expenditure on health as percentage of GDP in EU-28 was 7% of GDP and for EU-19 (Euro area) this indicator was 7.1% of GDP [26]. As it is noted in recent news release No. 33.2020 of Eurostat that in the EU in 2018 highest proportion of government expenditure goes to social protection (19, 2% of GDP) and health (7% of GDP) [27]. Nevertheless, among EU countries the values for total government expenditure varied from 2.7% of GDP in Cyprus till 8.3% of GDP in Denmark. Currently in many EU countries it is important to focus on healthcare finance, that needs structural changes regardless of demographic trends, in order to avoid cumulative effect of debts and secure enough funds to meet growing needs [28].

It is should be noted that the problem of the funding healthcare in EU and OECD is studied in many articles and reports, researchers try to argue the variety of financial mechanisms for funding healthcare in different countries according their socio-economic factors, traditions, institutional features, demographic characteristics and specifics of morbidity [29–32].

Many researches describe traditional general models of financing and funding healthcare such as Semashko model, public-contract model (Bismarkian model), the national health insurance model, mixed private/public system [33, 34]. Nevertheless, the features of financial mechanism for funding healthcare in the different countries

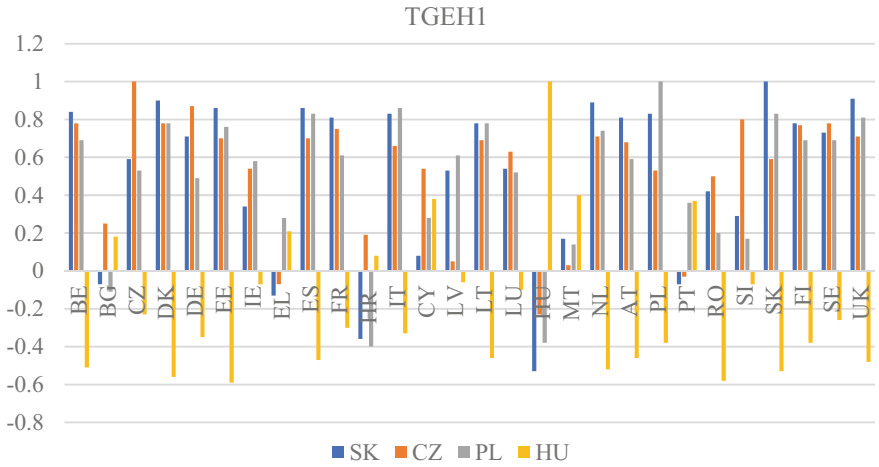

Fig. 3 The pair correlations for the total government expenditure on health as % of GDP (TGEH1) for Visegrad countries and other countries of EU. *Source* Own calculation for the data from Eurostat for period of 2000 till 2017

should be analyze more detail and more specifications of national models of funding healthcare should be revealed.

At first for analysis of the common policy in the EU concerning funding healthcare we calculated the correlation matrices for three main indicators mentioned earlier. For example of Visegrad countries, namely Slovakia, Czech Republic, Poland and Hungary, the results of the calculations of pair correlations with other countries of EU are presented in Figs. 3, 4 and 5.

On the basis of the calculations of the correlation matrices for EU-28 we observed, that for most countries the tendencies for indicators, such as: total government expenditure on health as % of GDP (TGEH1), total government expenditure on health as % of total general government expenditure (TGEH2); total government expenditure on health per capita (TGEH3) are multi correlated, matrix determinants for the correlation matrices of these indicators are very closed to 0 [35]. Thus, it means that in general for all countries of the EU the main macroeconomic indicators for funding healthcare are coordinated. It is should be noted, that there are the significant positive, as well as negative values of the pair coefficients of correlation for these indicators.

These facts reflect the different character of changes in tendencies between some pair of countries. In some pairs of countries, where the significant positive pair correlations are observed, the increase of the change in the values of indicator for one country met the increase of the change in the values of the same indicator for second country, and vice versa. In the case of existing strong negative pair correlations between some countries, we can see, that the increase of the change in the values of the indicator in one country met the reduce of the change in the values of same indicator for second country, and vice versa. Thus, more detail information about

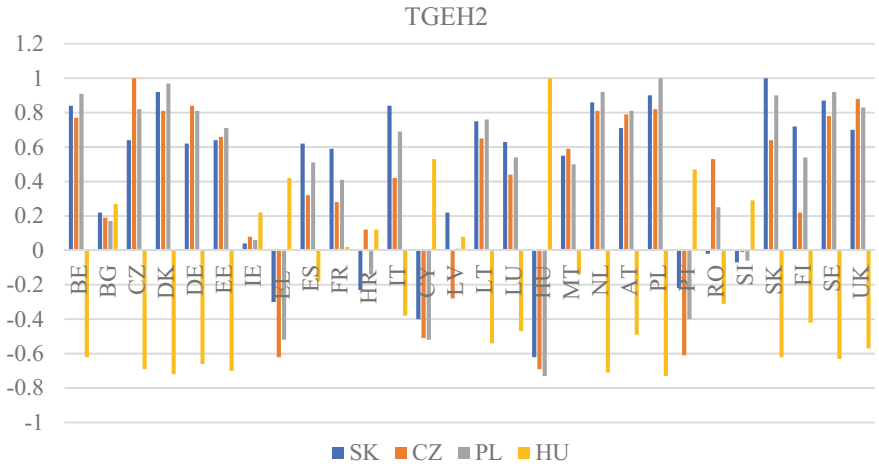

Fig. 4 The pair correlations for the total government expenditure as % of total general government expenditure (TGEH2) for Visegrad countries and other countries of EU. *Source* Own calculation for the data from Eurostat for period of 2000 till 2017

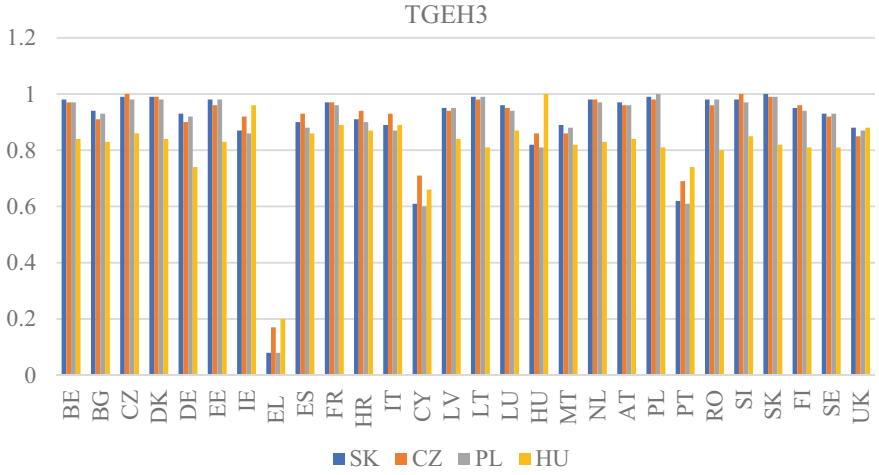

Fig. 5 The pair correlations for the total government expenditure on health per capita (TGEH3) for Visegrad countries and other countries of EU. *Source* Own calculation for the data from Eurostat for period of 2000 till 2017

the relationship of these indicators for separate countries and pair coefficients of the correlation may be analyzed.

In the next stage of this research, we studied more detail the features of the dynamics of tendencies for the main macroeconomic indicators such as: total government expenditure on health as % of GDP (TGEH1), total government expenditure on

health as % of total general government expenditure (TGEH2), for total government expenditure on health per capita (TGEH3) [26, 36, 37]. The graphical analysis of the plots for the dynamics of the indicators TGEH1, TGEH2 and TGEH3 for each country of the EU-28 during period of 2000–2017, as well as the study of their basic descriptive statistics for mentioned indicators showed that for many countries of the EU-28 the tendencies to increase values were observed. In some countries the values of these indicators were varied near average level, in other countries the more complicated changes in the values of the indicators were revealed, when during some period the values were growing till level and then dramatically were falling.

These facts proved that on the dynamics of the main macroeconomic indicators (total government expenditure on health as % of GDP—TGEH1; total government expenditure on health as % of total general government expenditure—TGEH2; total government expenditure on health per capita—TGEH3) a lot of social, economic, political factors can have an impact. Of course, for many countries in transition, post socialist countries, which join to the EU since 2004 the initial values of total government expenditure on health per capita were much more low, in comparison with well-developed countries from Western Europe [26, 30, 32, 38, 39]. Due to the crucial reforms in healthcare sector, structural investment programs from the EU, rapid economic growth in these countries the tendencies of the increasing total government expenditure on health per capita or total government expenditure on health as % of GDP were observed. Nevertheless, in some countries of the EU the change in the political impact for leading political parties, political or economic crises influenced on essential changes in national models of funding healthcare [30, 38].

To demonstrate the features of the tendencies of the main indicators used for the analysis of the funding healthcare and predictions of their development it is necessary to provide descriptive statistics and analysis of time series.

For the reason of the different regimes in the funding healthcare in the EU-28 countries for long-run period, we studied two basic models: (1) model based on the linear trend and (2) exponential smoothing with linear trend (Holt's model) [35, 36, 40, 41]. Second model was used for the description of more complicated process than classical linear development, because exponential smoothing has important property such as adaptation of the recent values based on the changes of previous levels.

Exponential smoothing is based on the idea, that each new smoothed value (forecast) is calculated as the weighted average of the current observation and the previous smoothed observation. Thus, in effect, each smoothed value is the weighted average of the previous observations, where the weights decrease exponentially depending on the value of parameter α. If α is equal to 1then the previous observations are ignored entirely, if α is equal to 0, then the current observation is ignored entirely, and the smoothed value consist of the previous smoothed value. Value of α in-between produce intermediate results [41]. When in Holt's model a trend component is included in the exponential smoothing process, an independent trend component is computed for each time and modified as a function of the forecast error and the respective parameter γ. If the parameter γ is 0, it means that the trend component is constant across all values of the time series and for all forecasts. If the parameter

Table 4 Analysis of variance

	Between		Within		Signif.	
	SS	df	SS	df	F	p
X	470.4755	4	518.6642	499	113.1596	0
Y	945.9238	4	2235.044	499	52.79716	0
Z	5.5E+08	4	25,739,546	499	2667.019	0

Source Own elaboration in Statistica

γ is 1, then the trend component is modified "maximally" from the observation to observation by the respective forecast error [41, 42].

The results of the modelling of the tendencies of funding healthcare in the EU countries-28 are described in our previous papers [36, 37].

Next stage is grouping the countries of the EU-28 to similar groups or clusters according to their values of the indicators $TGEH_1$, $TGEH_2$ and $TGEH_3$ [36]. For the grouping the countries of the EU-28 we used data for period of 2000–2017 and k-means method of cluster analysis [40, 41]. On the base of the analysis of dendrograms and results of the analysis of variance for the different number of clusters, as well as results of their qualitative interpretation, we concluded that number of 5 clusters is the best variant according to the interpretation and results of the analysis of variation. The results of analysis of variation for 5 clusters are given in Table 4 [43].

In the Table 5 the descriptive statistics are shown for clusters.

As it is seen from Table 5, cluster No. 1 contains 21 cases, this cluster characterizes the highest value of total government expenditure on health per capita (indicator $TGEH_3$ or Z), the means for other indicators $TGEH_1$ or X (total government expenditure on health as % of GDP) and $TGEH_2$ or Y (total government expenditure on health as % of total general government expenditure) have relatively high values, but not the biggest.

Cluster 2 contains 92 cases, the mean of indicator $TGEH_1$ or X (total government expenditure on health as % of GDP) and $TGEH_2$ or Y (total government expenditure on health as % of total general government expenditure) are the biggest, the countries of the EU-28 with extremely high values of $TGEH_1$ and $TGEH_2$ were concentrated in this cluster. Also countries of the EU-28 included in this cluster have very high value of $TGEH_3$ or Z (total government expenditure on health per capita) in comparison with countries in other clusters, such as: cluster No. 4 and Cluster No. 5.

Cluster 3 contains 93 cases, in this cluster are relatively high all values of indicators $TGEH_1$ or X (total government expenditure on health as % of GDP) $TGEH_2$ or Y (total government expenditure on health as % of total general government expenditure) and $TGEH_3$ or Z (total government expenditure on health per capita). But the mean for indicator of $TGEH_3$ is essentially less than in cluster No. 1 and cluster No. 2, but more than 1.7 times mean value for cluster No. 4 and more than 4.5 times mean value for cluster No. 5

Cluster 4 contains 111 cases and characterizes relatively high values for indicators $TGEH_1$ or X (total government expenditure on health as % of GDP) and $TGEH_2$

Table 5 The characteristics of clusters for grouping the EU-28 countries according the different regimes of funding healthcare during period of 2000–2017

Variable	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5	
	Cluster contains 21 cases		Cluster contains 92 cases		Cluster contains 93 cases		Cluster contains 111 cases		Cluster contains 187 cases	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
X	6.75	1.86	7.23	0.92	6.64	0.77	6.34	0.79	4.8	1.16
Y	13.58	2.26	15.12	1.97	14.03	1.41	14.36	2	11.71	2.5
Z	4007.39	342.64	2860.85	251.59	2030.03	237.06	1141.22	214.57	446.22	199.42

Source Own elaboration in Statistica

or Y (total government expenditure on health as % of total general government expenditure) and relatively low level of $TGEH_3$ or Z (total government expenditure on health per capita).

Cluster 5 contains 187 cases and the features of this cluster are the lowest mean values for all indicators, such as: $TGEH_1$ or X (total government expenditure on health as % of GDP,) $TGEH_2$ or Y (total government expenditure on health as % of total general government expenditure) and $TGEH_3$ or Z (total government expenditure on health per capita).

In Table 6 the results of grouping countries of the EU-28 are presented for period of 2000–2017 [43].

It is should be noted that most of the EU-28 countries switched the regimes of the funding healthcare systems, it is proved that over period of 2000–2017 they moved from one kind of cluster to another one. For most countries this switches from one type of cluster to another one occurred after long period, that it is possible to suggest the results of the economic development, new strategies of government, maybe after change of leading political party and other priorities in social or budget policies. Nevertheless, some countries demonstrated the stable policy in funding their national healthcare and over all period these countries were in the same cluster.

For example, cluster No. 5 or "trap of poverty" included post socialist and emerging countries which were in this cluster all period of 2000–2017 or long time period. Such countries as: Bulgaria, Croatia, Cyprus, Latvia, Hungary and Poland were in this cluster all period of 2000–2017. Other countries were in this cluster for long time period: Czechia (2000–2005), Estonia (2000–2014), Lithuania (2000–2016), Malta (2000–2005), Slovakia (2000–2017). After some improving the funding healthcare systems and increasing total government expenditure on health per capita these countries moved to cluster No. 4. Greece started from cluster No. 5 in 2000 to better cluster No. 4, nevertheless as a reaction on the global economic and financial crisis of 2008–2012 and internal political and economic crisis this country returned to cluster No. 5 in 2014 and in 2015. Portugal was in cluster No. 5 in 2000 and then moved to cluster No. 4. In cluster No. 5 Slovenia was in 2000 and 2001, then it moved to cluster No. 4.

For all period of 2000–2017 in cluster No. 4 only one country was, this is Spain. In cluster No. 4 a lot of countries of the EU-28 stayed long time period, such as: Czechia (2006–2017), Greece (2001–2013, 2016, 2017), Malta (2010–2017), Portugal (2001–2017), Slovenia (2002–2017), Slovakia (2008–2017). In 2000 such countries as: Belgium, Ireland, Italy, Netherlands, Finland and the United Kingdom were in cluster No. 4.

In cluster No. 3, cluster No. 2 and cluster No. 1 no countries were for all period of 2000–2017, nevertheless, a lot of countries were for long time period. In cluster No. 3 a lot of countries were for long time period: France (2000–2009), Belgium (2001–2008), Italy (2004–2017), Austria (2000–2006), Sweden (2000–2006), the United Kingdom (2001–2013).

In cluster No. 2 some countries were for long time period: Belgium (2009–2017), Ireland (2004–2017), Netherlands (2007–2017), Austria (2008–2016), Finland (2008–2017) and Sweden (2010–2017). Some countries of the EU-28 were in this

Table 6 Grouping the EU-28 countries to the clusters during period of 2000–2017

	2000	2005	2010	2015	2016	2017
Belgium	CL4	CL3	CL2	CL2	CL2	CL2
Bulgaria	CL5	CL5	CL5	CL5	CL5	CL5
Czechia	CL5	CL5	CL4	CL4	CL4	CL4
Denmark	CL3	CL2	CL1	CL1	CL1	CL1
Germany	CL3	CL3	CL3	CL2	CL2	CL2
Estonia	CL5	CL5	CL5	CL4	CL4	CL4
Ireland	CL4	CL2	CL2	CL2	CL2	CL2
Greece	CL5	CL4	CL4	CL5	CL4	CL4
Spain	CL4	CL4	CL4	CL4	CL4	CL4
France	CL3	CL3	CL2	CL2	CL2	CL2
Croatia	CL5	CL5	CL5	CL5	CL5	CL5
Italy	CL4	CL3	CL3	CL3	CL3	CL3
Cyprus	CL5	CL5	CL5	CL5	CL5	CL5
Latvia	CL5	CL5	CL5	CL5	CL5	CL5
Lithuania	CL5	CL5	CL5	CL5	CL5	CL4
Luxembourg	CL3	CL2	CL1	CL1	CL1	CL1
Hungary	CL5	CL5	CL5	CL5	CL5	CL5
Malta	CL5	CL5	CL4	CL4	CL4	CL4
Netherlands	CL4	CL3	CL2	CL2	CL2	CL2
Austria	CL3	CL3	CL2	CL2	CL2	CL1
Poland	CL5	CL5	CL5	CL5	CL5	CL5
Portugal	CL5	CL4	CL4	CL4	CL4	CL4
Romania	CL5	CL5	CL5	CL5	CL5	CL5
Slovenia	CL5	CL4	CL4	CL4	CL4	CL4
Slovakia	CL5	CL5	CL4	CL4	CL4	CL4
Finland	CL4	CL3	CL2	CL2	CL2	CL2
Sweden	CL3	CL3	CL2	CL2	CL2	CL2
United Kingdom	CL4	CL3	CL3	CL2	CL2	CL2

Source Own elaboration in Excel

cluster a shorter period: Denmark (2002–2007), Germany (2013–2017), Luxembourg (2003–2007), the United Kingdom (2014–2017).

In long time period cluster No. 1 with the highest level of total government expenditure on health per capita includes cases from two counties of the EU-28: Denmark

(2008–2017) and Luxembourg (2008–2017). Austria had occurred in this cluster only in 2017.

To predict the future positions into the clusters for the EU-28 countries on period 2020–2021 we used the forecasts for indicators $TGEH_{1,}$ $TGEH_2$ and $TGEH_3$ on period 2020–2021 (Tables 7, 8 and 9) and discriminant function for recognition of type of clusters for new cases.

In Table 7 the predicted values for indicator TGEH1 or X (total government expenditure on health as % of GDP) are given.

In Table 8 the predicted values for indicator TGEH2 or Y (total government expenditure on health as % of total general government expenditure) are given.

In Table 9 the predicted values for indicator TGEH3 or Z (total government expenditure on health per capita) are presented.

The results of the construction of discriminant function are given in Table 10.

As it is seen from this table the discriminant function has good accuracy, the Wilks' Lambda is closed to 0, values for F-remove criteria are statistically significant at level $p < 0.01$ [41].

The estimations of the classification functions are presented in Table 11. In discriminant analysis the linear functions are usually used, by means them it is possible to recognize the clusters for new cases. For new case the values of variables are inserted in all classification functions and the biggest value of related classification functions determines in what cluster new case will occur.

Then we used the results of forecasts on 2020–2021 from Tables 7, 8 and 9 for the discriminant or classification functions (Table 11) and the results of the predictions of clusters according to the different scenarios were obtained in Table 12.

As it is clear seen from Table 12, we created predictions for different scenarios and demonstrate the possible regimes of the funding healthcare and their changes for some countries in the EU-28 for period of 2020–2021.

For such countries, as: Bulgaria, Cyprus, Latvia, Hungary, Poland, Romania the predicted regime is cluster No. 5 for the different scenarios, it means that for all presented forecasts of values for indicators $TGEH_{1,}$ $TGEH_2$ and $TGEH_3$ no any principal changes and the regime of funding healthcare stays as it was earlier. To mode regime from cluster No. 5 to Cluster No. 4, which is better, it is necessary to improve significantly values of some indicators, mainly $TGEH_3$ (total government expenditure on health by capita), but it is a problem for post socialist and emerging countries with relatively low GDP and income per capita. Thus, only in long run perspective it is possible to expect that these countries leave cluster No. 5 or "trap of poverty".

Another stable perspective to stay in the same regime of funding healthcare or to be in the same cluster, that it was earlier, we can see for some countries of the EU-28. For example, Estonia, Lithuania, Malta, Portugal and Slovakia will stay in cluster No. 4; Germany, France and the UK will occur in cluster 2, Denmark and Luxembourg will stay in cluster No. 1. For other countries of the EU-28 we can see some changes of the regimes of funding healthcare according to the different scenarios.

Table 7 The results of the predicted values of total government expenditure on health as % of GDP for 2020–2021

Country	2020				2021			
	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
	Lower 95% interval	Prediction for linear trend model	Upper 95% interval		Lower 95% interval	Prediction for linear trend model	Upper 95% interval	
Belgium	7.85	8.39	8.93	8	7.91	8.49	9.07	8.1
Bulgaria	4.27	5.05	5.82	5.09	4.25	5.08	5.91	5.16
Czechia	7.33	7.72	8.11	7.62	7.33	7.75	8.16	7.66
Denmark	8.5	9.12	9.74	8.74	8.56	9.22	9.88	8.84
Germany	6.96	7.23	7.5	7.24	6.98	7.27	7.56	7.28
Estonia	5.07	5.5	5.93	5.12	5.11	5.56	6.02	5.16
Ireland	5.21	6.45	7.68	5.15	5.14	6.46	7.78	5.17
Greece	4.39	5.15	5.9	5.13	4.28	5.09	5.9	5.11
Spain	6.12	6.62	7.13	6.14	6.14	6.68	7.22	6.19
France	8.1	8.39	8.68	8.19	8.13	8.44	8.76	8.25
Croatia	5.56	6.18	6.81	6.26	5.5	6.17	6.84	6.25
Italy	6.98	7.42	7.86	6.96	6.99	7.47	7.94	7.01
Cyprus	2.48	2.75	3.01	2.62	2.46	2.74	3.02	2.62
Latvia	3.48	3.97	4.47	3.48	3.45	3.98	4.51	3.46
Lithuania	5.48	6.26	7.05	5.84	5.48	6.32	7.16	5.89
Luxembourg	4.72	5.13	5.55	5.1	4.73	5.17	5.61	5.17

(continued)

Table 7 (continued)

Country	2020				2021			
	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
	Lower 95% interval	Prediction for linear trend model	Upper 95% interval		Lower 95% interval	Prediction for linear trend model	Upper 95% interval	
Hungary	4.41	4.77	5.14	4.78	4.35	4.74	5.13	4.75
Malta	5.23	5.65	6.07	5.52	5.22	5.67	6.12	5.56
Netherlands	7.87	8.89	9.91	8.14	7.98	9.07	10.17	8.31
Austria	8.14	8.35	8.56	8.39	8.19	8.41	8.63	8.46
Poland	4.64	4.93	5.23	4.84	4.65	4.97	5.28	4.89
Portugal	5.84	6.51	7.18	6.18	5.77	6.48	7.2	6.18
Romania	3.75	4.17	4.59	4.32	3.75	4.2	4.65	4.32
Slovenia	6.33	6.68	7.03	6.6	6.31	6.69	7.06	6.6
Slovakia	7.18	7.78	8.37	7.56	7.25	7.89	8.53	7.66
Finland	7.37	8.2	9.03	7.35	7.4	8.29	9.17	7.43
Sweden	6.81	7.09	7.37	7.09	6.83	7.13	7.43	7.16
United Kingdom*	7.67	8.32	8.97	7.81	7.75	8.45	9.14	7.94

* Since 1 February, 2021 United Kingdom is not a member of the EU
Source Own elaboration in Statistica

Table 8 The results of the predicted values of total government expenditure on health as % of total general government expenditure

Country	2020				2021			
	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
	Lower 95% interval	Prediction for linear trend model	Upper 95% interval		Lower 95% interval	Prediction for linear trend model	Upper 95% interval	
Belgium	14.92	15.31	15.69	15.2	15.02	15.43	15.84	15.34
Bulgaria	11.77	13.68	15.59	14.73	11.74	13.79	15.84	15
Czechia	18.61	19.2	19.79	19.36	18.73	19.37	20.01	19.51
Denmark	16.35	16.96	17.57	17.13	16.5	17.15	17.81	17.35
Germany	16.34	16.71	17.08	16.47	16.46	16.86	17.25	16.58
Estonia	13.14	13.58	14.01	12.89	13.19	13.66	14.12	12.92
Ireland	15.99	18.23	20.46	19.98	15.91	18.31	20.7	20.21
Greece	7.75	9.15	10.55	10.84	7.42	8.92	10.43	10.78
Spain	13.65	14.39	15.14	14.76	13.63	14.43	15.22	14.84
France	14.09	14.36	14.63	14.34	14.09	14.38	14.67	14.38
Croatia	12.35	13.58	14.81	13.63	12.27	13.59	14.91	13.63
Italy	14.03	14.7	15.36	14.26	14.04	14.76	15.47	14.34
Cyprus	5.86	6.38	6.89	6.78	5.77	6.32	6.87	6.77
Latvia	8.76	9.87	10.97	9.21	8.65	9.83	11.02	9.15
Lithuania	16.66	17.62	18.59	18.15	16.8	17.83	18.86	18.41
Luxembourg	11.23	11.8	12.38	11.79	11.24	11.86	12.48	11.88
Hungary	9.22	9.79	10.35	10.08	9.11	9.72	10.32	10.03
Malta	13.72	14.66	15.59	15.64	13.78	14.78	15.78	15.83
Netherlands	19.23	20.21	21.19	19.29	19.61	20.66	21.71	19.7
Austria	15.99	16.42	16.85	17.01	16.09	16.55	17.01	17.17
Poland	11.49	11.88	12.27	11.74	11.58	12	12.42	11.87
Portugal	11.62	12.77	13.92	13.6	11.38	12.61	13.84	13.55
Romania	10.55	11.63	12.7	13.22	10.56	11.71	12.86	13.34
Slovenia	12.65	13.61	14.57	15.06	12.56	13.59	14.62	15.13
Slovakia	17.7	19.38	21.05	19.05	17.91	19.71	21.51	19.49
Finland	13.35	14.32	15.29	13.25	13.34	14.38	15.42	13.31
Sweden	14.28	14.59	14.9	14.43	14.4	14.74	15.07	14.61

(continued)

Table 8 (continued)

Country	2020				2021			
	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
	Lower 95% interval	Prediction for linear trend model	Upper 95% interval		Lower 95% interval	Prediction for linear trend model	Upper 95% interval	
United Kingdom*	18.1	18.54	18.98	18.95	18.28	18.75	19.22	19.18

* Since 1 February, 2021 United Kingdom is not a member of the EU
Source Own elaboration in Statistica

Thus, during last long-run period included almost two decades Slovakia demonstrated the steady development and progress in the main indicators for funding her healthcare system. After 2007 Slovakia left cluster of No. 5 or "trap of poverty" and moved to cluster No. 4, where such countries of EU like Greece, Malta, Spain, Portugal were located. It is should be note that during last years, Slovakia and other post socialist countries like Czechia, Hungary, Slovenia were together in cluster No. 4 and it was demonstrated some principle changes in the reforms of healthcare systems in the mentioned countries. Nevertheless, a lot of problems for further reforms and enhancement in the systems of healthcare should be solved for Slovakia and other post socialist countries or countries in transition.

6.1 Discussion

The comparative analysis of Slovakia and other European countries is useful to understand better the problems of the organization and financing of healthcare in Slovakia on the background of the other countries. Such kind of the analysis and application of statistical methods and modelling allow to reveal the tendencies in the changes of the main indicators which are important for the description of the national healthcare systems.

Simpler models were used for an initial analysis of the dynamics of the main macroeconomic indicators of financing health systems in the EU. Despite the assumption that there is an absolute convergence of these indicators for the EU countries in the long term [44], it is nevertheless necessary to test the hypotheses of conditional convergence, when for certain groups of countries there will be their own tendencies to which these countries will follow in the long term. In addition to simple time series models, an analysis of other more complex models, such as, for example, ARIMA, should be carried out [40, 41, 45].

Table 9 The results of the predicted values of total government expenditure on health per capita for 2020–2021

Country	2020				2021			
	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
	Lower 95% interval	Prediction for linear trend model	Upper 95% interval		Lower 95% interval	Prediction for linear trend model	Upper 95% interval	
Belgium	2976.11	3285.76	3595.42	3223.08	3032.63	3363.93	3695.23	3308.13
Bulgaria	343.23	392.21	441.2	409.17	355	407.41	459.81	426.31
Czechia	1293.56	1486.78	1680.01	1513.9	1323.93	1530.66	1737.39	1567.48
Denmark	4261.71	4695.24	5128.78	4626.53	4340.73	4804.56	5268.4	4746.16
Germany	2692.22	2906.43	3120.64	3025.3	2740.3	2969.48	3198.66	3093.65
Estonia	876.43	1007.99	1139.56	1027.27	906.11	1046.87	1187.63	1068.9
Ireland	3055.16	3439.36	3823.56	3473.9	3097.75	3508.8	3919.85	3578.19
Greece	693.57	992.24	1290.91	901.46	669.15	988.69	1308.23	909.26
Spain	1487.81	1686.45	1885.09	1610.18	1507.21	1719.74	1932.26	1649.52
France	2763.89	2961.61	3159.32	2939.67	2803.49	3015.02	3226.55	3001.4
Croatia	696.71	796.05	895.38	812.23	706.36	812.64	918.91	834.12
Italy	1962.18	2158.61	2355.04	2061.18	1978.61	2188.77	2398.93	2100.25
Cyprus	555.75	662.87	769.99	629	554.76	669.37	783.97	641.23
Latvia	476.67	576.11	675.55	547.05	489.55	595.93	702.32	567.41
Lithuania	800.69	935.63	1070.56	954.31	827.21	971.58	1115.94	993.24
Luxembourg	4639.14	5132.74	5626.35	5030.26	4736.44	5264.53	5792.63	5184.02
Hungary	568.75	639.64	710.54	667.31	576.74	652.59	728.44	687.69
Malta	1204.68	1332.43	1460.18	1461.18	1234.29	1370.97	1507.65	1507.43
Netherlands	3321.76	3823.9	4326.03	3623.86	3395.12	3932.34	4469.56	3738.96
Austria	3370.16	3624.72	3879.28	3720.51	3434	3706.36	3978.71	3811.46
Poland	551.99	632.87	713.76	637	566.52	653.06	739.6	659.83
Portugal	1096.89	1250.07	1403.25	1258.1	1099.88	1263.77	1427.65	1281.7
Romania	372.65	429.49	486.34	472.88	386.35	447.17	507.99	492.74
Slovenia	1329.77	1462.26	1594.74	1496.24	1351.77	1493.52	1635.26	1534.61
Slovakia	1123.28	1319.39	1515.49	1266.7	1161.1	1370.9	1580.71	1318.97
Finland	2963.93	3374.15	3784.38	3118.86	3011.84	3450.73	3889.62	3199.36
Sweden	3203.63	3536.6	3869.57	3539.11	3256.79	3613.03	3969.27	3622.64

(continued)

Table 9 (continued)

Country	2020				2021			
	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
	Lower 95% interval	Prediction for linear trend model	Upper 95% interval		Lower 95% interval	Prediction for linear trend model	Upper 95% interval	
United Kingdom*	2715.05	2983.01	3250.96	2831.83	2758.18	3044.86	3331.54	2896.41

* Since 1 February, 2021 United Kingdom is not a member of the EU
Source Own elaboration in Statistica

Table 10 Results of the discriminant function analysis

No. of vars in model: 3; Grouping: CLUSTERH (5 grps)						
Wilks' Lambda: 0.03592 approx. F (12.1315) = 275.74 $p < 0.0000$						
	Wilks' Lambda	Partial Lambda	F-remove (4.497)	p-level	Toler	1-Toler (R-Sqr.)
X	0.037932	0.946982	6.956296	1.87E−05	0.539411	0.460589
Y	0.036892	0.973679	3.358802	0.009971	0.548501	0.451499
Z	0.504672	0.071176	1621.419	0	0.97593	0.02407

Source Own elaboration in Statistica

Table 11 Classification functions

Grouping: CLUSTERH					
	CL1	CL2	CL3	CL4	CL5
	$p = 0.04167$	$p = 0.18254$	$p = 0.18452$	$p = 0.22024$	$p = 0.37103$
X	1.166	2.036	2.264	2.237	1.542
Y	1.982	2.25	2.077	2.314	2.062
Z	0.075	0.052	0.036	0.019	0.006
Constant	−171.557	−100.912	−60.515	−35.947	−18.105

Source Own elaboration in Statistica

It is also necessary to take into account that the studied variables $TGEH_1$, $TGEH_2$ and $TGEH_3$ are interdependent, since in these variables the numerator of the fraction is the same, and the denominators are different. At the same time, it is not enough to use only one indicator for analysis (usually most scientists used for the analysis only $TGEH_1$ or total government expenditure on health as % of GDP). It is necessary to apply all three mentioned indicators, since this takes into account the characteristics

Table 12 The results of the predictions of clusters according to the different scenarios

Type of scenario	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Coordinates for predictions	(x_L;y_L;z_L)		(x_U;y_U;z_U)		(x,y,z)		(x_Hl,y_Hl,z_Hl)	
Year	2020	2021	2020	2021	2020	2021	2020	2021
Belgium	CL2	CL2	CL1	CL1	CL2	CL2	CL2	CL2
Bulgaria	CL5	CL5	CL5	CL5	CL5	CL5	CL5	CL5
Czechia	CL4	CL4	CL3	CL3	CL4	CL4	CL4	CL4
Denmark	CL1	CL1	CL1	CL1	CL1	CL1	CL1	CL1
Germany	CL2	CL2	CL2	CL2	CL2	CL2	CL2	CL2
Estonia	CL4	CL4	CL4	CL4	CL4	CL4	CL4	CL4
Ireland	CL2	CL2	CL1	CL1	CL2	CL2	CL2	CL1
Greece	CL5	CL5	CL4	CL4	CL4	CL4	CL5	CL4
Spain	CL4	CL4	CL3	CL3	CL3	CL3	CL3	CL3
France	CL2	CL2	CL2	CL2	CL2	CL2	CL2	CL2
Croatia	CL5	CL5	CL4	CL4	CL4	CL4	CL4	CL4
Italy	CL3	CL3	CL3	CL3	CL3	CL3	CL3	CL3
Cyprus	CL5	CL5	CL5	CL5	CL5	CL5	CL5	CL5
Latvia	CL5	CL5	CL5	CL5	CL5	CL5	CL5	CL5
Lithuania	CL4	CL4	CL4	CL4	CL4	CL4	CL4	CL4
Luxembourg	CL1	CL1	CL1	CL1	CL1	CL1	CL1	CL1
Hungary	CL5	CL5	CL5	CL5	CL5	CL5	CL5	CL5
Malta	CL4	CL4	CL4	CL4	CL4	CL4	CL4	CL4
Netherlands	CL2	CL2	CL1	CL1	CL1	CL1	CL1	CL1
Austria	CL2	CL2	CL1	CL1	CL1	CL1	CL1	CL1
Poland	CL5	CL5	CL5	CL5	CL5	CL5	CL5	CL5
Portugal	CL4	CL4	CL4	CL4	CL4	CL4	CL4	CL4
Romania	CL5	CL5	CL5	CL5	CL5	CL5	CL5	CL5
Slovenia	CL4	CL4	CL4	CL3	CL4	CL4	CL4	CL4
Slovakia	CL4	CL4	CL4	CL4	CL4	CL4	CL4	CL4
Finland	CL2	CL2	CL1	CL1	CL2	CL2	CL2	CL2
Sweden	CL2	CL2	CL1	CL1	CL1	CL1	CL1	CL1
United Kingdom*	CL2	CL2	CL2	CL2	CL2	CL2	CL2	CL2

* Since 1 February, 2021 United Kingdom is not a member of the EU

Note x_L; y_L; z_L—coordinates for lower 95% of interval of the forecasts for linear trend; x_U; y_U; z_U—coordinates for upper 95% of interval of the forecasts for linear trend; x, y, z—coordinates of the forecasts for linear trend; x_Hl, y_Hl, z_Hl—coordinates for forecasts based on Holt's model

Source Own elaboration in Statistica

of economic growth, socio-economic policy, budget priorities, and the level of well-being of the country and its population.

In this regard, it is necessary to consider the structural equations between the individual components of the variables $TGEH_1$ (total government expenditure on health as % of GDP), $TGEH_2$ (total government expenditure on health as % of total general government expenditure) and $TGEH_3$ (total government expenditure on health per capita), the possible control parameters to achieve the goals and improve regime of the funding healthcare in studied country of the EU. Some restrictions obtained on macroeconomic indicators of healthcare financing can be used in further optimization problems or in optimal control problems for adjustment of long-run policy in healthcare.

The scenario approach used in the work gives a broader picture of the possible variants of development trends of the main macroeconomic indicators used to describe the modes of financing health systems. At the same time, the scenarios that were developed on the basis of long-term trends showing the usual development expected from the point of view of historical data do not take into account possible jumps or sudden changes taking into account the global impact of the pandemic caused by Covid-19, which are possible for forecasts for 2020 and 2021 years. So, it is possible to assume a decrease in GDP in many countries due to the freezing of the economy, the implementation of mass quarantine measures, and the restriction of human resource mobility. On the other hand, it is possible to increase total health care costs due to the fact that this industry is now one of the highest priorities due to the massive risks of infection; the complexity of certain clinical cases require expensive medical equipment, long-term treatment and experienced medical personnel; the costs of strengthening sanitary and hygienic measures, provision of personal protective equipment, and the mass application of tests for diagnostics will also increase significantly. Besides the significant investments will be required to develop national vaccines, their clinical trials or to purchase vaccines produced in other countries.

Thus, many of the tasks set in the work can be studied and analyzed in more detail for cases of Slovakia and other European countries.

7 Conclusions

Thus, in this work, we set the goals and obtained the following conclusions: For the EU-28 countries, the hypothesis of the existence of absolute convergence of the main macroeconomic indicators such as: $TGEH_1$ (total government expenditure on health as % of GDP), $TGEH_2$ (total government expenditure on health as % of total general government expenditure) and $TGEH_3$ (total government expenditure on health per capita) is confirmed over the long term period. At the same time, hypotheses about the presence of sigma-convergence and conditional convergence should be tested for individual groups of countries, which may have their own separate paths for the development of health system financing processes.

To describe the features of financing national health systems in the EU countries, it is necessary to use not one, the most common indicator, but a set of indicators, such as: $TGEH_1$ (total government expenditure on health as % of GDP), $TGEH_2$ (total government expenditure on health as % of total general government expenditure) and $TGEH_3$ (total government expenditure on health per capita).

For simple models of analysis and forecasts, it is sufficient to use simple models, such as a linear trend, exponential smoothing models, such as Holt's models. At the same time, for more detailed studies and forecasts for individual countries, it is advisable to use other, more advanced models, such as: ARIMA, VAR, etc. [45].

As a result of using these three mentioned main macroeconomic variables and methods of cluster analysis (k-means), five clusters were obtained that describe various modes of financing health systems in the EU-28 for 2000–2017. It was shown that for some groups of countries during this long period there were no changes in the modes of financing health systems, while for other countries there were long-term or short-term changes in regimes of funding healthcare [46].

It should be noted that in some countries the policy of financing health systems was quite flexible and changed, while in other countries this policy was stable for a long term period. At the same time, a number of social, economic, political and institutional factors influence the policy of financing health systems, which should also be taken into account and studied in connection with the changing characteristics of financing the health system in the country.

The application of the scenario approach, based on the use of different forecast results of the main macroeconomic indicators of financing the health care system, using these forecasts and discriminant functions to recognize whether new cases belong to given clusters it made possible to determine the various regimes of financing health care systems for the period 2020–2021.

The study of the features of individual health system financing regimes for the EU countries should also be supplemented by studies of the material and human resources, capacities of national health systems, indicators of their functioning, the quality of the provision of medical services, and assessments of the effectiveness of health systems in terms of public health.

The results of the study can be used for a more detailed study of the policy of financing the health system in Slovakia, as well as for other European countries.

References

1. Szalay, T., et al.: Health systems in transition: Slovakia. Eur. Observatory Health Syst. Policies **13**(2), 1–200 (2011) [Online]. http://www.euro.who.int/__data/assets/pdf_file/0004/140593/e94972.pdf
2. Zachar, D.: Health system in the Slovak Republic (2013) [Online]. http://www.ineko.sk/clanky/publikacie
3. Srebalová, M.: Development of public administration terminology (with special regard to the concept of administrative body) at present. Adm. Law. Year **39**(4), 249–264 (2006). ISSN 0139-6005

4. Smatana, M., Pažitný, P., Kandilaki, D., Palušáková, M., Ginneken, E., Spranger, A.: Slovakia health system review. Health Syst. Trans. **18**(6) (2016). ISSN 1817-6127
5. Morvay, K. a kol.: Healthcare. Markets, regulation and politics. HPI (2013). https://www.hpi.sk/category/publikacie/zdravotnictvo-trhy-regul
6. Kováč, M.: Analysis of current approaches and methods of citizens' security measurement. Contemp. Res. Organ. Manage. Adm. Research Papers **3**(2), 43–54 (2015). ISSN 2335-7959
7. Kabát, Filip, S., Filipová, L.: Safety measurement peculiarities in selected countries. J. Secur. Sustain. Issues: Int. Entrepreneurial Perspect. Innovative Outcomes **6**(3), 343–356 (2017). ISSN 2029-7017 (SCOPUS)
8. Gavurová, B.: Dlhodobá zdravotná starostlivosť na Slovensku – analýza jej potenciálu a štruktúrnych determinantov [The Long-term care delivery in Slovakia: an analysis of its potential and structural determinants]. Technical University Košice, Košice (2016)
9. Gavurová, B., Štoltés, V., Kafková, K.: Selected aspects of Slovak healthcare effectivity. Day surgery and its development in conditions of SK. Technical University Košice, Košice (2013)
10. Szalayová, A., Skybová, K., Kandilaki, D., Szalay, T.: Analýza lekárenského trhu na Slovensku a v Českej Republike [Analysis of pharmacies market in Slovakia and Czech Republic] (2014) [Online]. http://www.hpi.sk/cdata/Publications/hpi_analyza_lekarenskeho_trhu.pdf. Accessed 12 May 2016
11. Fraser, I., Encinosa, W., Glied, S.: Improving efficiency and value in health care: introduction. Health Res. Educ. Trust 1781–1786 (2008). https://doi.org/10.1111/j.1475-6773.2008.00904.x
12. Eurostat Health Database (online). Databáza - Zdravie - Eurostat (europa.eu)
13. OCD/European Observatory on Health Systems and Policies: Slovakia: Country Health Profile 2021, State of Health in the EU, OECD Publishing, Paris/European Observatory on Health Systems and Policies, Brusel (2021). ISBN 9789264764095 (PDF) Series: State of Health in the EU SSN 25227041 (online)
14. HIP: 10 years of Healthcare Reform: summary (2014) Online. 10 rokov reformy: súhrn zmien | HPI - Stredoeurópsky inštitút pre zdravotnú politiku
15. Perez, V., Benitez, J., Ross, J.: Too small to fail: The role of Medicaid in mitigating pandemic-related fiscal strain on local governments. Publ. Budgeting Finance **41**(3), 74–97 (2021). ISSN 02751100. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85110943876&doi=10.1111%2fpbaf.12298&partnerID=40&md5=df73e0f1b32d142f9d82a8c843bce2b2
16. Peráček, T., Vojtech, F., Srrebalová, M.: Restriction on the re-export of medicinal products and the supervision of compliance with it by public administration bodies. Eur. Pharm. J. **65**(1), 24–30 (2018) [online]. ISSN (print) 2453-6725. https://content.sciendo.com/view/journals/afpuc/65/1/article-p24.xml (In SCOPUS)
17. Meričková Mikúšová, B., Štrangfeldová, J., Srebalová, M., Peráček, T.: Selected economic and legal aspects of availability of drugs in Slovak Republic. Farmaceutický obzor.—vintage N 86(1–2), 12–21 (2017). ISSN 0014-8172 (SCOPUS)
18. Simões, J., Magalhães, J.P.M., Biscaia, A., da Luz Pereira, A., Augusto, G.F., Fronteira, I.: Organisation of the State, model of health system and COVID-19 health outcomes in six European countries, during the first months of the COVID-19 epidemic in 2020. Int. J. Health Plan. Manage., Open Access **36**(5), 1874–1886 (2020), September 2021. ISSN 07496753. https://doi.org/10.1002/hpm.3271 (SCOPUS)
19. Bedrunka, K., Mach, Ł., Kuczuk, A., Bohdan, A.: Identification and analysis of structural fund support mitigating the effects of the COVID-19 pandemic in the EU—a case study of health unit funding. Energies **14**(16), art. no. 4976 (2021). ISSN 19961073
20. Wright, J.S., Turner, S.: Integrated care and the 'agentification' of the English National Health Service (2020). https://doi.org/10.1111/spol.12630
21. Hahn, U., Bauling, Ch., Brzoska, P.: Structures of outpatient medical care: Germany and other decentrally organized healthcare systems. Gesundheitswesen **83**(5), 337–344 (2021). https://doi.org/10.1055/a-1390-3935
22. Health Care Surveillance Authority: OZNAMENIE_podiel-PP_3.1.web_.pdf (udzs-sk.sk) (2022)

23. Ministry of Health of the Slovak: Proposal of hospital network according to levels, accessibility and catchment. Ministerstvo zdravotníctva Slovenskej republiky (gov.sk) (2022)
24. Ministry of Health of the Slovak: Type and extent of healthcare provision at given levels. Ministerstvo zdravotníctva Slovenskej republiky (gov.sk) (2022)
25. Eurostat. Database. https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
26. Dubrovina, N., Tulai, O., Neuvauerova, E.: Tendencies of funding health care in EU countries: the features and perspectives. In: Nestorenko, T., Ostenda, A. (eds) Monograph "Theoretical and Applied Aspects of Sustainable Development". Katowice School of Technology, Katowice, pp. 12–22 (2020)
27. Highest proportion of government expenditure goes to social protection and health (2020). Eurostat newsrelease No. 33/2020 from 27 February 2020. https://ec.europa.eu/eurostat/documents/2995521/10474879/2-27022020-AP-EN.pdf/4135f313-1e3f-6928-b1fd-816649bd424b
28. Dixon, A.: Learning from international models of funding and delivering health care. In: Oxford Handbook of Public Health Practice. Oxford University Press (2006)
29. Benova, E., Dubrovina, N., Boyko, V., Zamyatin, P.: Classification and cluster analysis of health care systems in the OECD countries. J. Publ. Adm. Reg. Dev. Sch. Econ. Manage. Publ. Adm. **X**(2), 45–56 (2014)
30. Docteur, E., Oxley, H.: Health-care systems: lessons from the reform experience. OECD Health Working Papers. No. 9 (2003)
31. Funding health care: options for Europe. In: Mossialos, E., Dixon, A., Figueras, J., Kutzin, J. (eds.). Open University Press, Philadelphia, USA, 327 pp (2002)
32. Jakubowski, E., Busse, R.: Health care systems in the EU. A comparative study. Working Paper. European Parliament, Luxembourg, 130 pp (1998)
33. Joumard, I., André, C., Nicq, C.: Health care systems: efficiency and institutions. OECD, Economics Department Working Papers, No. 769 (2010)
34. Kostičová, M., Ozorovský, V., Badalík, L., Fabian, G.: An Introduction to Social Medicine. Bratislava, p. 150 (2011)
35. Kozlíková, K., Trnka, M.: Úvod do spracovania a prezentovania dát v medicíne. EQUILIBRIA, s.r.o., Košice, p. 226 (2018)
36. Dubrovina, N., Gerrard, R., Filip, S., Dubrovina, V.: Modelling the trends of the healthcare funding in the EU countries. J. Przegląd europejski **2021**(1), 61–80 (2021) (Warsaw University)
37. Dubrovina, N., Dubrovina, V., Filip, S.: Modelling of the tendencies of funding healthcare in the EU countries. In: Magda, R. (ed.) Economics and Management in times of change. Proceedings of the 1st Online International Scientific Conference, Szent Istvan University, Hungary, pp. 26–37 (2020). ISBN 978-80-89654-75-8
38. Boulhol, H., et al.: Improving the health-care system in Poland. OECD Economics Department Working Papers, No. 957, OECD Publishing. https://doi.org/10.1787/5k9b7bn5qzvd-en
39. Health care in Central and Eastern Europe: reform, privatization and employment in four countries. International Labour Organization, 59 pp (2002)
40. Dostal, P.: Pokročilé metody analýz a modelováni v podnikatelství a verejné správé. Brno, CERM, p. 340 (2008)
41. Borovikov, V.: Statistica: iskusstvo analiza dannych na kompjutere. Dlya professionalov. SPb., Piter, p. 656 (2001)
42. Holt's forecasting model. In: Swamidass, P.M. (ed.) Encyclopedia of Production and Manufacturing Management. Springer, Boston, MA (2000)
43. Dubrovina, N., Filip, S., Dubrovina, V.: Classification of financial mechanisms of healthcare systems in the countries of European Union. In: Itema 2020. Conference Proceedings. 4th International Scientific Conference on Recent Advances in Information Technology, Tourism, Economics, Management and Agriculture—ITEMA 2020, Belgrade, pp. 169–176 (2020)
44. Dubrovina, N., Azhazha, M., Nestorenko, T.: Analysis of the convergence of main indicators for funding healthcare in the EU countries. In: International Relations 2020: Current Issues of World Economy and Politics. Proceedings of Scientific Works from the 21th International Scientific Conference 3rd–4th December 2020. Publishing Ekonóm, pp. 174–184 (2020)

45. Harris, R., Sollis, R.: Applied Time Series Modelling and Forecasting, p. 302. Wiley, England (2003)
46. European Commission: Joint report on health systems. Occasional Papers, No. 74 (2010)

Legislation on the Distribution of Financial Services in Selected EU Member States and the Innovative Way of Financial Intermediation in the Slovak Republic

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Abstract The regulation of financial intermediation has evolved dynamically over the last eleven years and has undergone numerous changes. The increasing regulatory burden can be attributed to the fact that financial agents make a significant contribution to the conclusion of financial service contracts. By distributing financial products, they contribute to the profits of financial institutions, the financial intermediaries in the economy. Just as the financial crisis (and, nowadays, the pandemic crisis) has resulted in the legislation, whether national or European, increasing the demands placed on financial institutions, the demands placed on the distributors of their services are also logically increasing. In this context, the authors discuss the legal regulation of the distribution of financial services in selected EU Member States and at the same time reflect on the broker pool model as a way of conducting financial intermediation in the Slovak Republic.

1 Introduction

The need for a uniform regulation of sales channels of financial services resulted from the Resolution of the Government of the Slovak Republic of 1 August 2007 No. 624/2007, which approved the Concept of consumer protection in the field of financial services, provision of financial education and regulation of intermediary activities and advisory activities on the financial market (hereinafter referred to as the "Concept") [1].

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A proposal of an act on financial intermediation was drafted on the basis of the Concept. The text of the regulation was the result of a public professional debate, as seven associations of financial institutions, financial intermediaries and advisors and other financial market professionals and two consumer organizations sent comments. The aim was to increase the demands on intermediaries and advisors and their access to clients, but without seriously disrupting the business environment; it was also necessary to prevent activities carried out without any professional training and outside the supervision of the National Bank of Slovakia.

The regulation of financial intermediation and financial advisory reflects the idea of creating a level playing field [2] and the need to ensure supervision [3]. The Act No. 186/2009 Coll. on Financial Intermediation and Financial Advisory and on Amendments and Additions to Certain Acts, as amended (hereinafter referred to as the "Financial Intermediation Act") unified the conditions for carrying out financial intermediation and financial advisory.

The Financial Intermediation Act represents the fulfilment of the legislator's deliberate plan to unify the conditions for the distribution of financial services in the insurance or reinsurance, capital market, supplementary pension saving, old-age pension saving, deposit-taking, lending, consumer credit and housing credit sectors.

The legislation in question introduces, inter alia, a distinction between financial advisory [4] and financial intermediation. In the first quarter of 2022, according to the data publicly available from the website of the National Bank of Slovakia, eight entities were licensed to act as financial advisors. Financial advisory as a sui generis business has therefore not yet developed its potential and, given the regulatory environment obliging the client to pay a fee to the financial advisor for his services, cannot be expected to do so even in the future.

On the contrary, the number of entities eligible for financial intermediation reaches to several tens of thousands, among which we pay attention to the category of independent financial agents and subordinate financial agents.

The main objective of the paper is to present a set of de lege ferenda considerations on the basis of the analysis carried out. The paper also aims to orient the reader on selected legal aspects of the regulation of the distribution of financial services in selected EU Member States. The partial objectives of the paper are represented by providing the characteristics of the categories of financial agents, namely independent and subordinate financial agent, as well as presenting the legal relationships existing within the broker pool.

In the context of the above mentioned objectives, we set out to test the following hypothesis:

H: The legal regulation of financial intermediation in the Slovak Republic is at a sufficient level.

2 Methods of Scientific Research

A method can be defined as a set of rules defining a class of operational procedures leading from a starting point (base) to a goal [5]. The general logical methods that are used are represented by deduction, induction and abduction [6].

The deductive method uses deductive reasoning to know the truth [4]. The inductive method is applied in such a way that, based on the examination of written documents, certain partial knowledge of particulars, having the logical character of statements about particulars, is obtained, from which, based on certain rules, general conclusions of the highest degree of probability are drawn [4].

Abduction makes it possible to relate individual facts to each other and, on this basis, to create a general rule [6].

General scientific methods include not only general logical methods, but also other general scientific methods such as analysis, synthesis, comparison, analogy, generalization, specification, abstraction, idealization, model, etc. [6].

Analysis, synthesis and comparison were also used to obtain the outputs. Analysis is an operation in which an object, phenomenon or process will be mentally or factually decomposed into its constituent elements [7].

We characterize the analysis as a sequential collection of information [8]. The individual parts, obtained on the basis of the thought decomposition of the phenomenon under study, become the subject of further investigation and critical evaluation [9].

Financial intermediation carried out in the category of independent financial agent represents a range of social relations regulated by law, in particular by the legal branch of financial law. We decompose financial law rules as the phenomenon under study and view their interaction in terms of increasing the possibilities of selling financial services through subordinate financial agents.

Compared to analysis, synthesis is the opposite process, it is the unification of the composition of a process from its basic elements into a whole, and this unification does not have to be just the sum of the individual parts that were previously divided by analysis [7].

Synthesis represents the mental unification of individual parts into a whole, enabling knowledge of the interrelationships between phenomena and the structure of the whole [7]. At the same time, we synthesize the obtained knowledge on the implementation of financial intermediation by an independent financial agent through subordinate financial agents into de lege ferenda considerations.

The comparative method is used when comparing the Slovak regulation of financial intermediation with the European regulation as well as with the regulation in selected EU Member States. The comparative method consists in comparing the law of one or more foreign states to the law of one's own or another state [10]. The comparative method is linked to the possibility of knowing the legal status of the legal order of a foreign state [11].

The essence of the comparative method is comparison, i.e., the object of comparative consideration is always at least two elements, one of which is the comparatum (i.e., that which is being compared) and the other is the comparandum (that which is

to be compared with it), both of which must have some reasonable tertium comparationis, i.e., some common feature according to which they can be compared [12]. We consider it to be a common feature that all the EU Member States mentioned are part of the continental legal system, in which the normative legal act is one of the most important formal sources of law.

3 Analysis of Sources

Distribution of financial services in the Slovak Republic is an up to date topic, especially because the share of financial agents in intermediated financial services is constantly increasing. As well as due to the fact that the legislator has introduced into practice a unique regulation, which is not found in the surrounding European countries and belongs to the legal branch of financial law, namely to its sub-branch of financial market law, the research of which has long been devoted to M. Sidak, especially in the publication Regulation and Supervision of Financial Market Subjects' Activities.

A financial service in its broadest sense is a product that is of financial nature [13].

In order to determine the environment, in which a financial agent operates, i.e. in which, among other things, this subject distributes financial services, it seems appropriate to define the concept of the financial market.

The financial market, together with the market for goods, services and labor, constitutes a prerequisite for the proper functioning of the market economic system, enabling the movement of capital, the redistribution of free funds from entities possessing a surplus of these funds to entities in need of financial resources [14]. A financial market is a materially motivated, institutionally organized buying and selling of money [15].

The financial market can also be defined as a system of relationships, instruments, entities and institutions enabling the accumulation, distribution and allocation of temporarily free money on the basis of supply and demand, i.e. on a voluntary contractual basis [16].

We come across various criteria designed to classify the financial market. P. Musílek distinguishes, according to the criterion of traded instruments, stock markets, bond markets and financial derivatives markets [17].

O. Rejnuš divides the financial market into money, capital and foreign exchange markets; the money market consists of short-term credit and short-term securities; the capital market consists of long-term credit and long-term securities; the foreign exchange market is divided into foreign exchange and foreign currency markets [3].

B. Chovancová divides the market into money, capital, foreign exchange, insurance and gold and precious metals markets [5]. With regard to the maturity of traded instruments, we distinguish between money and capital markets [18]. In the money market, entities bridge a temporary shortage of funds, i.e. it is a market for short-term financial instruments (with a maturity of up to one year), while the capital market focuses on long-term financial instruments with a maturity of more than one year [19].

The current legislation allows the following categories of financial agents to be active on the financial market, in terms of distribution of financial services—tied financial agent, subordinated financial agent, supplementary insurance intermediary, tied investment agent and independent financial agent unless otherwise provided for in the Financial Intermediation Act [20].

The tied financial agents represent the distribution channel with which the financial institution cooperates. The term financial institution can generally be characterized as all entities that conduct business and offer their financial services to potential or existing clients in the financial system [21]. Legal definition of a financial institution for the purposes of the Financial Intermediation Act is found in Article 4 of the legislation in question.

According to Article 8 of the Financial Intermediation Act, the tied financial agent will be authorized to act for one financial institution in the relevant sector at the same time. Attention should be paid to the insurance or reinsurance sector, in which the tied financial agent may carry out financial intermediation simultaneously for an insurance undertaking carrying on exclusively non-life insurance business and for one insurance undertaking carrying on exclusively life insurance business.

The National Bank of Slovakia does not grant authorization to tied financial agents to carry out financial intermediation activities. They carry out financial intermediation on the basis of registration in the register kept by the supervisory authority [22].

It is an electronically maintained database of persons authorized to carry out financial intermediation on the territory of the Slovak Republic, for each sector in which these persons are authorized to operate [23].

According to Article 14 Paragraph 2 of the Financial Intermediation Act, the application for their registration shall be made by the proposer, responsible for compliance with the statutory conditions by the subordinated entities. The tied financial agent shall also be subject to delegated supervision by the proposer [24, 25], which verify whether a given entrepreneur complies with the relevant legal standards regulating financial intermediation. It is necessary to distinguish the concept of delegated supervision from the supervision carried out by the National Bank of Slovakia. According to Article 1 Paragraph 3 of the Act No 747/2004 Coll. on Financial Market Supervision as amended, the tied financial agent is not one of the supervised entities of the financial market.

The tied financial agent will be part of its proposer's network and its activities will be determined to some extent by the instructions of the supervisor relating to the conduct of financial intermediation.

The feature of autonomy of the legal definition of business of financial intermediation according to Article 2 Paragraph 1 of the Act No. 513/1991 Coll. Commercial Code as amended, of entrepreneur will be fulfilled, but will be influenced in particular by the provisions of a innominate contract concluded with the proposer, as well as the range of powers conferred on the proposer by the Financial Intermediation Act.

Financial intermediation may be performed also by a supplementary insurance intermediary. Where the proposer for registration of the supplementary insurance intermediary is a financial institution, the provisions governing a tied financial agent

shall apply to its activities and, where the applicant is an independent financial agent, those applicable to a subordinated financial agent.

The supplementary insurance intermediary is one of the entities subject to compulsory delegated supervision [26].

The legislation of the Financial Intermediation Act does not apply to a supplementary insurance intermediary, provided that the following conditions are cumulatively met.

Firstly, the nature of the insurance as a supplement to the goods sold or service provided and also the de minimis nature of the premium, which may not exceed EUR 600 calculated on an annual basis, or EUR 200 per person for a service, unless the insurance protection (period) lasts for more than three months [27].

A tied investment agent is a special entity in the field of financial intermediation in the capital market sector, operating for an exhaustively defined circle of persons and whose activity is, unlike other types of financial agents in the capital market sector, not limited to investment services referred to in Article 12 of the Financial Intermediation Act, but may intermediate investment services to the extent permitted by the person it represents, i.e. the represented person [27].

The tied investment agent is subject to facultative delegated supervision by its proposer, which is not mandated by the Financial Intermediation Act, but the exercise of which is in the interest of the supervisor, as the tied investment agent is acting under its full and unconditional responsibility [26]. In particular, the tied investment agent seeks out clients and promotes the entity under whose responsibility it acts [28].

In particular, the legal regulation of the distribution of financial services is dealt with by M. Sidak, E. Hajnišová, A. Nádaský, P. Jedinák, P. Mikloš, Z. Turčanová, M. Winkler, in the commentary to the Financial Intermediation Act, as well as A. Slezáková, P. Tkáč and M. Novotná in the monograph Independent Financial Agent as a Supervised Entity of the Financial Market, D. Kravecová in Financial Intermediation—How to perform Business Legally, or M. Gürtler Financial Intermediation and Financial Advisory on the Insurance Market in the Slovak Republic.

4 European Regulation in Selected Member States

A level playing field as a principle for creating equal conditions [29] and equal opportunities in competition [30] was one of the central ideas behind the adoption of the Financial Intermediation Act. The way in which the issue of financial intermediation is regulated represents a decision by the legislator [27].

Integrated regulation of financial intermediation and financial advisory in different sectors does not exist in European Union law, which is characterized by a sectoral approach which, moreover, is not fully interlinked and harmonized, even in directly related areas such as the distribution of financial instruments (under MiFIDII) and insurance-based investment products (under IDD) [27]. This lack of consistency at the level of European rules, which are the basis for implementation in national law, thus poses a major challenge for national legislators [27].

The only area where we find a degree of harmonization in the regulation of the distribution of financial services is in the insurance or reinsurance sector. Excerpts from the legal regulation of this issue in selected Member States in the sector in question are provided in the following.

4.1 Czech Republic

The regulatory environment in the Czech Republic differs from that in the Slovak Republic in that there is no single normative legal act regulating the distribution of financial services for all sectors of the financial market. The regulation in question can be found in a set of special laws, which corresponds to the legal situation in Slovakia in force and effective until 31 December 2009.

The Act No. 170/2018 Coll. on Insurance and Reinsurance Distribution as amended (hereinafter referred to as the "Insurance Distribution Act") constitutes sector-specific legislation.

The present normative legal act transposes the IDD Directive in the Czech Republic. It distinguishes the following categories of entities authorized to mediate insurance or reinsurance. According to Article 5 Paragraph 1 of Insurance Distribution Act these are an independent intermediary, a tied agent, a supplementary insurance intermediary and an insurance intermediary with a home Member State other than the Czech Republic. According to Article 5 Paragraph 2 of the Insurance Distribution Act the insurance intermediation by an insurance company and reinsurance intermediation by a reinsurance company is also being regulated.

An independent financial agent authorized to carry on business in the insurance or reinsurance sector is closer to the category of independent intermediary. Only certain common features can be discussed, as the regulations of both countries also show significant differences.

An independent intermediary arranges insurance or reinsurance on the basis of an authorization to act as an independent intermediary granted by the Czech National Bank.

The common feature with the Slovak regulation is a certain kind of interference by the competent supervisory authority, which will conduct the licensing procedure.

According to Article 8 Paragraph 1 of the Insurance Distribution Act only electronic filing is allowed. From the point of view of submitting an application for the relevant authorization, with the Act No. 67/2020 Coll. on Certain Emergency Measures in the Financial Sector in Relation to the Spread of the Dangerous Contagious Human Disease COVID-19 as amended, the legislator made it possible for applicants to deliver to the National Bank of Slovakia, during the pandemic period, applications for authorization also electronically signed with a qualified electronic signature; however, this is a right, not an obligation, of the applicant [31]. The possibility to apply for authorization to act as an independent financial agent in paper form remains unchanged [31].

An individual administrative act granting a participant the authorization to act as an independent intermediary shall not be delivered and shall enter into force upon entry in the register kept by the Czech National Bank.

When comparing the positive decision of the Czech National Bank with the positive decision of the National Bank of Slovakia, which grants the relevant authorization, the Czech regulation appears to be more flexible and more suitable for the needs of the current pandemic times. In the Slovak regulation there is no possibility of electronic execution, the authorization to act as an independent financial agent is ex lege in writing and must be delivered.

In terms of subordinates, an independent agent is entitled to build a network of subordinates who are bound agents. The uniqueness of the Czech legislation lies in the fact that tied agents enter into a contract with the independent intermediary, or with an insurance or reinsurance company, or with an insurance intermediary with a home Member State other than the Czech Republic as a proposer.

For the category of tied agent, the Insurance Distribution Act provides the possibility to form a sales channel of a financial institution (insurance company, reinsurance company) or an independent intermediary or an entity from another Member State (other than the Czech Republic). It is the tied agent's decision with which entrepreneur to enter into a contract, while at the same time the contractual relationship may exist exclusively with one represented.

The Slovak legislator distinguishes between the distribution network of a financial institution formed by tied financial agents and the distribution network of an independent financial agent formed by subordinated financial agents. These are two different categories of financial agents.

A key difference is also the impossibility for a financial intermediary from another Member State (other than the Slovak Republic) in the insurance or reinsurance sector to apply for the registration of subordinated entities. According Article 14 and following Financial Intermediation Act a financial intermediary from another Member State in the insurance or reinsurance sector does not fall within the exhaustively defined range of applicants for registration, meaning this entity is not entitled to build its own distribution network in the territory of the Slovak Republic.

4.2 Republic of Austria

The Austrian regulation relating to the distribution of financial services in the insurance or reinsurance sector can be found in BGBl. Nr. 194/1994 Gewerbeordnung as amended (hereinafter referred to as the "Austrian Trade Licensing Act"). The IDD has been transposed into Austrian law, inter alia, by amending the Austrian Trade Licensing Act [32].

The Austrian Trade Licensing Act distinguishes between regulated trades, part-time trades and free trades in terms of the prerequisites for obtaining a trade license [2].

Regulated trades are exhaustively defined in Article 94 of the Austrian Trade Licensing Act. Among them, the legislator has included commercial property consultancy and insurance mediation in point 75 and point 76 of the Article 137 of the Austrian Trade Licensing Act. This regulation does not prohibit the same entity from holding a trade license for commercial property consultancy and insurance mediation.

The difference lies in the scope of the authorization to distribute financial services. A commercial property adviser is authorized to arrange life and accident insurance only and, under the conditions laid down by the Austrian Trade Licensing Act, may also be active in the arranging of investments (with the exception of investment instruments) and selected types of credit.

An insurance intermediary is not restricted by the legislation in the range of insurance products, which this subject is authorized to distribute. Article 137 Paragraph 1 of the Austrian Trade Licensing Act defines insurance intermediation as

1. Advising, recommending or carrying out other preparatory work for the conclusion of insurance contracts;
2. The conclusion of insurance contracts or assistance in their administration and in the provision of benefits, in particular in the event of loss;
3. The provision of information on one or more insurance policies on the basis of criteria selected by the client through a website or other medium, as well as the ranking of insurance products, including price and product comparisons or premium discounts, where the client can conclude an insurance contract directly or indirectly through a website or other medium; or
4. The activities referred to in points 1 to 3 in relation to reinsurance contracts.

The significant difference is that Austrian regulation (compared to Slovak) allows the insurance intermediary to receive remuneration from the insurance company and the client at the same time. However, only from the client if the advice has been given and the remuneration in question has been expressly agreed in the individual case. The purpose of the activity of an insurance intermediary is to arrange the conclusion of an insurance contract.

Therefore, the Austrian legislator explicitly states that if the insurance company for arranging the conclusion of the insurance contract remunerates the insurance intermediary, the remuneration from the client is reduced by that amount. According to Article 138 Paragraph 1 of the Austrian Trade Licensing Act, in case of doubt, the insurance intermediary shall be deemed to have been paid by the insurance undertaking the locally customary remuneration. It can be stated that the client pays the intermediary for the advice. The concept in question differs fundamentally from the Slovak legislation, which does not allow for the cumulating of financial intermediation and financial advisory.

Another significant difference lies in the fact that the Slovak legislator, when defining a trade negatively, says in Article 3 Paragraph 2 of the Act No. 455/1991 Coll. on Trade Business as amended that financial intermediation is not a trade, whereas in Austria, the regulation in question can be found in the Austrian Trade Licensing Act.

5 Characteristics of Slovak Regulation of Selected Categories of Financial Agents

5.1 Subordinate Financial Agent

A subordinate financial agent enters into a contractual relationship with an independent financial agent [25]. The basis of their cooperation is a written contract, usually a commercial agency agreement. At the same time, the subordinate financial agent can only have a written contract with one independent financial agent. Typically, this entity will be an individual who works in a large distribution network of an independent financial agent, often operating on the multi-level marketing principle, which provides for the division of remuneration between several levels of sales [27]. The scope of the authorization to act as an independent financial agent (counterparty) and the written contracts entered into with financial institutions in the relevant sector directly determine the activities of the subordinated financial agent. It follows that a subordinate financial agent may therefore only offer financial services that its counterparty is authorized to broker. Subordinated financial agents are obliged to comply with the authorizations of the independent financial agent ensuring the proper performance of the activity, which will be contractually enshrined [27].

The register of financial agents, financial advisers, financial intermediaries from another Member State in the insurance or reinsurance sector and tied investment agents (hereinafter generally referred to as "the register") plays a key role in the commencement of the activities of a subordinated financial agent. It is maintained by the National Bank of Slovakia. The subordinated financial agent must be entered in the register.

The proposer for its entry in the register is the independent financial agent (it has a login name and password) [27]. In this context, we view the electronic application for registration as an outgrowth of an existing contractual relationship [27]. In order for the registration to take place, two cumulative conditions must be fulfilled, namely the completeness of the application and the payment of the fee [27]. The National Bank of Slovakia does not examine whether the proposed subordinated entity complies with the legal requirements for the performance of the activity when registering; the proposer is responsible for the correctness and completeness of the data in accordance with Article 14 Paragraph 3 of the Financial Intermediation Act.

In the case of a subordinate financial agent, entry in the register can be analogous to the constitutive effects of an individual administrative act creating a new legal situation [27]. Of course, we underline the word by analogy, because registration in the register is not a type of individual administrative act, but the effects are analogous, since the legislation speaks of the authorization of the subordinate financial agent to carry out the activity from the date of registration.

We speak of analogous constitutive effects only if the other statutory conditions for the performance of the activity are fulfilled (liability insurance for the performance of financial intermediation in accordance with Article 30 Paragraph 6 first sentence and Paragraph 7 first sentence of the Financial Intermediation Act).

The National Bank of Slovakia shall electronically notify the independent financial agent—the proposer of the registration.

This creates an ex lege obligation to issue a certificate of registration to the subordinate entities, the model of which shall be laid down in the Annex No. 4 of the Decree of the National Bank of Slovakia No. 5/2013 on the register of financial agents, financial advisors, and financial intermediaries from another Member State in the insurance sector or reinsurance and tied investment agents. A written document proves enrolment. It is mainly used for the purpose of legitimizing oneself in front of the client [25].

5.2 Independent Financial Agent

The correlation between financial and commercial regulation is reflected in the business of all supervised financial market entities. The most significant supervised financial market entity is the bank. It is a key institutional investor, which in practice usually also uses independent financial agents to distribute its services. The same is true for insurance companies, securities dealers, asset management companies, pension management companies and supplementary pension companies. At the same time, many of these financial institutions even operate as an independent financial agent [33].

The topic of financial intermediation regulation is therefore an ever-present one. We believe that this trend will continue for a long time to come in the light of the pitfalls arising from application practice.

In terms of the opportunities offered by the legislator to engage in financial intermediation, the independent financial agent is a category characterized by cooperation with financial institutions. An independent financial agent is entitled to offer competing financial products; ergo it has the potential to attract clients with a wide range of financial services, as it has the possibility of concluding written contracts with several financial institutions operating in the relevant sector at the same time.

The written contract, which the legislation requires to be concluded in accordance with Article 7 of the Financial Intermediation Act, shall be represented in particular by a commercial agency agreement [34]. In transitional provisions, the Financial Intermediation Act transformed entities that were operating under specific sectoral legislation in force until 31 December 2009. Insurance agent, reinsurance intermediary, investment services intermediary and intermediary authorized to act for two or more supplementary pension funds were included in the relevant sectors.

The independent financial agent is as a natural person—entrepreneur or a legal person with a license to carry out financial intermediation. The independent financial agent belongs to the supervised entities of the financial market. The authorization to act as an independent financial agent is being granted by the National Bank of Slovakia. The independent financial agent is required to have a place of business, registered office, and organizational unit in the territory of Slovakia accordance with Article 6 of the Financial Intermediation Act.

When performing financial intermediation, the all finance approach is a possible strategy. This is a diversification strategy, the aim of which is to offer the client a variety of financial services "from one source" [35]. In terms of practice, these will be independent financial agents who are authorized to operate in all six sectors.

The legislation allows an independent financial agent to build up a network of subordinate financial agents, if the legal conditions are met. As a superior entity, the independent financial agent carries out "delegated supervision" over the subordinated entities.

The independent financial agent shall set out in a written contract with the subordinate financial agent the set of rights, which the independent financial agent will exercise against the subordinate financial agent under Article 29 Paragraph 4 of the Financial Intermediation Act. Where, by virtue of a contractual relationship with a financial institution, an independent financial agent is entitled to collect monies, we consider that it is obliged to set up a special account for this purpose [25]. This regulation serves to protect funds intended for a financial institution or a client or third party beneficiary of a financial service contract [25].

The segregation of funds into a separate account only confirms the fact that it is not the property of an independent financial agent. The funds are not included in the event of bankruptcy [25].

An independent financial agent shall be liable for damage caused by him in the course of carrying out financial intermediation and shall be required to take out liability insurance. From the legal-theoretical point of view of the division of types of insurance according to the legal regulation, in accordance with the Act No. 40/1964 Coll. Civil Code as amended, we can distinguish between contractual insurance and statutory insurance [36]. Liability insurance for damage caused in the performance of financial intermediation can be classified as a subgroup of compulsory contractual insurance, where the legislator, by means of a special regulation, obliges a natural or legal person to conclude an insurance contract [25].

The purpose of liability insurance is to ensure the protection of the insured against the adverse consequences of his liability, which could be devastating, as well as to ensure the protection of the injured party against the negative consequences of the lack of solvency of the entity that has caused the damage and is liable for it [37].

In relation to the professional liability function in question, we refer to the minimum amount of insurance cover set by the legislator in order to secure claims of injured clients of the independent financial agent that may arise in the future and the statutory limitation of the maximum amount of the deductible.

The contractual partner, i.e. the independent financial agent, may assume liability for damage caused by a subordinate financial agent in accordance with Article 30 Paragraph 6 and Paragraph 7 of the Financial Intermediation Act. Insurance companies on the Slovak insurance market reflect the provisions of the Financial Intermediation Act and offer "whole network" insurance.

5.3 Building a Network of Subordinated Financial Agents

The goal of an independent financial agent's business is to continuously expand the tribe of clients. Logically, therefore, he will be interested in building up as large a network of subordinate financial agents as possible so that they can attract more customers.

There is no regulation in the Financial Intermediation Act that would determine the way subordinate financial agents are organized and their relationships with each other. Multi-level marketing has become established in the business of many independent financial agents.

Multi-level marketing is a system through which the parent company's products are sold through a network of dealers [38]. Multi-level marketing is a method of selling products directly to consumers through a distributor network made up of independent distributors who refer other distributors, with the income is derived from retail and wholesale profits, which are made up of payments for the total sales of products [39].

When carrying out financial intermediation, multi-level marketing is a system, in which a limited liability company acting as an independent financial agent contracts with subordinate financial agents who arrange for clients to enter into a contract for the provision of a financial service. At the same time, the subordinated financial agents recruit other persons interested in the business in question.

In practice, it is possible to encounter arrangements in innominate contracts under which one subordinate financial agent (natural or legal person) "manages" a certain organizational unit made up of subordinate financial agents (it may also be called a trading division). This is the model used by broker pools.

In this business model, the subordinate financial agent also receives remuneration for the financial services distributed by the subordinate financial agents it has directly or indirectly "brought" into the business of independent financial agent. The highest remuneration is generated by the subordinate financial agents who are at the top or just below the top of the imaginary pyramid in question.

An organizational unit (business division) consists of a set of subordinated financial agents with whom the limited liability company has had the opportunity to enter into an innominate contract on the basis of the contribution of the "primary" subordinated financial agent, or of each additional subordinated financial agent that is part of the division in question.

Despite the fact that each subordinate financial agent is an entrepreneur and thus conducts business independently, in practice a chain of subordinate financial agents arises under each other. Each additional subordinated financial agent (other than the "primary" subordinated financial agent) will have a provision in the innominate contract to be incorporated into the organizational unit created by the primary subordinated financial agent (and also a definition of the organizational unit in question for the purposes of the innominate contract).

The creation of the contract, as a bilateral legal act, will require two unilateral legal acts of two different parties (the independent financial agent and the subordinated

financial agent), which are addressed to each other and are identical in substance. It follows that there will be consensual expressions of intent by both parties as to the status of the subordinated financial agent ("non-primary") in the business unit. This is the model used by broker pools.

On the legal nature of the "management" of the subordinate financial agent's organizational unit by the "primary" subordinate financial agent, we state the following. We consider that it is a representation.

The distinction between the power of attorney as a unilateral legal act (external relationship) and the agreement concluded between the principal and the principal (internal relationship) is a necessity in the legal qualification between the agent, the principal and third parties [40].

Legal opinions on the effects of a power of attorney differ. A power of attorney is a certification or confirmation of the existence of a right of a person to represent another person [41].

A power of attorney is a unilateral legal act by which the principal declares to a third person or persons (external relationship) that he has authorized a certain person as an authorized person, i.e. as attorney-in-fact, to represent him to the extent specified in the power of attorney [42]. It is not correct to limit the effects of the power of attorney to declaratory ones from the point of view of the origin of the power of attorney in relation to third parties [40]. De lege lata, a power of attorney is a legal act that creates the authority to represent [40].

The internal relationship is constituted by a power of attorney agreement. A power of attorney agreement may be represented by any contract that establishes an internal relationship between the principal and the agent [43].

In our view, an innominate contract between an independent financial agent and a "primary" subordinate financial agent constitutes a power of attorney agreement; the instrument in which it is contained may include a power of attorney [44, 45]. However, the "primary" subordinate financial agent and the independent financial agent generally do not have an interest in disclosing the sensitive data contained therein to a third party (the subordinate financial agent of the organizational unit) [46, 47].

Therefore, the power of attorney will be executed on a different document. In relation to the subordinate financial agent ("non-primary"), the power of attorney will be decisive, which will imply the authority of the "primary" subordinate financial agent to act for the independent financial agent to the extent indicated. In the power of attorney in question, the independent financial agent authorizes the "primary" subordinated financial agent generally to control the performance of a minimum number of intermediated financial service contracts [48, 49].

We reiterate that the Financial Intermediation Act does not prohibit the described business model. However, we consider it undesirable due to the lack of protection of financial consumers because it is aimed solely at the sale of financial services. It favors quantity over quality. It incentivizes subordinate financial agents to broker as many financial service contracts as possible [50].

The question arises as to whether these actually meet the needs of a client, especially of nonprofessional client (financial consumers, a weaker party to the contract [44, 51]).

6 Conclusion

There is no regulation in the Financial Intermediation Act that would determine the way subordinate financial agents are organized. The broker pool model has become established in practice. The currently valid regulation also allows for an "internal" organizational structure dominated by the primary subordinate financial agent and a hierarchically organized group of subordinate financial agents below it.

The primary subordinate financial agent decides on the distribution of commissions, controlling the fulfilment of the conditions of trustworthiness and professional competence. It can be said that an autonomous branch is created in which the primary subordinate financial agent performs the tasks of an independent financial agent.

Thus, in a broker pool, it is possible to circumvent the Financial Intermediation Act by granting the primary subordinate financial agent the de facto status of an independent financial agent based on contractual arrangements anchored, for example, in an innominate contract by a company, which has a license to act as an independent financial agent.

In times of pandemic crisis, this way of conducting financial intermediation is used in particular in situations where the independent financial agent fails, has a network of subordinate financial agents and becomes part of a broker pool, i.e. the primary subordinate financial agent (effectively acting as an independent financial agent in relation to former subordinate financial agents) [50].

The abuse of a right is linked to the search for the boundary between the use of a right and its exercise in an unauthorized manner, which constitutes the exercise of a right in accordance with the letter of the law, but contrary to its purpose and spirit, involving the two levels of abuse of a subjective right and abuse of an objective right [45]. Abuse of objective law, based on the Roman law concept of in fraudem legis, sees a contradiction with the law, if one adheres to its literal wording, but circumvents its meaning [45].

Thus, we can conclude that the addressee of a legal rule behaves in accordance with it, but the result is a contradiction with the ratio legis. Since neither, the meaning nor the purpose of the Financial Intermediation Act is to create two categories of subordinate financial agents (primary and non-primary) [52].

In the light of the above, we conclude that we have not confirmed the hypothesis. There is room for legislative changes in the current and effective Slovak legislation, which we present in our de lege ferenda considerations.

Considerations de lege ferenda

The business of supervised entities of the financial market, and thus also of an independent financial agent, is an issue in which financial and commercial law rules

interact. Commercial law is based on the idea that an entrepreneur—an independent financial agent has the ability to establish itself in a competitive environment, otherwise it will be forced to cease its activity.

However, the contractual freedom and dispositive legal rules prevalent in commercial law end where the mandatory legal rules prevalent in financial law begin. In the implementation of financial intermediation, these have a significant impact on the activities of entities.

Consideration de lege ferenda No 1

There is no regulation in the Financial Intermediation Act that would determine the way subordinate financial agents are organized and their relationships with each other. Multi-level marketing has also become established in business practice.

There is no explicit regulation in the Financial Intermediation Act specifying the way in which subordinate financial agents carrying out financial intermediation for an identical parent entity are organized.

In the innominate contracts concluded by independent financial agents with subordinate financial agents, it is possible to encounter arrangements whereby one subordinate financial agent (natural or legal person) "leads" a certain organizational unit consisting of subordinate financial agents (it may also be called a "commercial division").

Organizational units are formed by a set of vertically arranged subordinate financial agents with which an independent financial agent has had the opportunity to enter into an innominate contract in accordance with Section 9 of the Financial Intermediation Act and in conjunction with Article 269 Paragraph of the Act No. 513/1991 Coll. Commercial Code as amended, on the basis of the involvement of the "primary" subordinate financial agent or each additional subordinate financial agent in the structure in question.

An independent financial agent concludes contracts with subordinate financial agents who arrange for clients to conclude a contract for the provision of a financial service. At the same time, these subordinate financial agents recruit other persons interested in the business of financial intermediation.

Despite the fact that the subordinate financial agent is an entrepreneur and conducts business independently, multi-level marketing leads to a chain of subordinate financial agents underneath each other.

Each additional subordinate financial agent (in addition to the primary one) may have a provision in the innominate contract for inclusion in the organizational unit created by the primary subordinate financial agent (and a definition of the organizational unit in question for the purposes of the innominate contract). In that business model, the subordinate financial agent also receives remuneration for the financial services distributed by the subordinate financial agents it has motivated to enter into an innominate contract with an independent financial agent.

In accordance with the principle of contractual freedom inherent in commercial law, and in the absence of explicit regulation in the Financial Intermediation Act, there will be no legal barrier to the procedure in question.

The statutory regulation of financial intermediation does not preclude a chain of subordinate financial agents under one another. We therefore propose to incorporate Article 9a into the Financial Intermediation Act as currently in force stating the following:

Article 9a

It is prohibited for a subordinate financial agent to take any instructions from another subordinate financial agent or to receive any monetary or non-monetary remuneration from a financial intermediation carried out by another subordinate financial agent.

Consideration de lege ferenda No 2

The professional guarantor of the independent financial agent makes a crucial contribution to the compliance of the (financial intermediation) business with the regulatory environment. This fact is also emphasized by the current legislation allowing for specialization.

So that the supervised financial market entity (independent financial agent) has one professional guarantor for each sector in which it is authorized to perform financial intermediation. At the same time, the legislator expressly prohibits a natural person from acting as a professional guarantor for two or more independent financial agents at the same time.

This is irrespective of whether the independent financial agent is a natural person or a legal person.

The designation of the professional guarantor and the demonstration of compliance with the statutory conditions specified exhaustively by the person proposed for the function in question shall be included in the application for authorization to act as an independent financial agent and its annexes.

In the authorization procedure, the National Bank of Slovakia verifies whether the natural person does not act as a professional guarantor for another independent financial agent. Should this be the case, the supervisory authority shall invite the party to the proceedings to remedy the deficiencies and complete the application for the relevant authorization. The authorization procedure is therefore an effective mechanism to prevent the cumulating of professional guarantor activities with several independent financial agents at the same time.

In the operative part of the decision of the National Bank of Slovakia, granting the authorization to carry out the activity of an independent financial agent does not specify the professional guarantor. However, the name and surname of the professional guarantor shall be published when the independent financial agent is entered in the register kept by the National Bank of Slovakia.

Other categories of financial agents, including subordinate financial agents, are obliged to establish the function of professional guarantor under the conditions laid down in the Financial Intermediation Act.

The legislator establishes expressly under which conditions it is obligatory to create the function of professional guarantor of a subordinate financial agent. It is where financial intermediation is carried, out through employees. At the same time, the obligations of the professional guarantor of the subordinate financial agent

are derived from the legislation in force. However, the legislator does not regulate situations of cumulating of the function in question for several categories of financial agents. Nor does it prevent them by regulating the conflict of interest institute enshrined in the Financial Intermediation Act.

Given the absence of regulation, in practice, a situation may potentially arise where a natural person is at the same time a professional guarantor of both an independent and a subordinate financial agent. The Financial Intermediation Act does not explicitly exclude the case of a subordinate financial agent whose proposer for registration in the register is the independent financial agent, i.e. its supervisor.

We consider that, when carrying out on-site or off-site supervision, the National Bank of Slovakia cannot subsume the above under the notion of a deficiency in activity. Therefore, no sanction or measure can be imposed for the removal and correction of the identified deficiencies. The Financial Intermediation Act does not preclude the professional guarantor of an independent financial agent from also being the professional guarantor of a subordinate financial agent.

However, we are of the view that the accumulation at issue has the potential to result in a human factors failure based on a concurrence of duties. Therefore, for example, the on-site supervision report may include a recommendation in which the National Bank of Slovakia recommends that the functions be split.

Consideration de lege ferenda No 3

The legal relationship between the independent and subordinate financial agent in a broad sense can be defined as a legally regulated social relationship, the content of which includes the provision of relevant outputs for the purpose of fulfilling the rules of business in relation to the client, education and transfer of know-how of the independent financial agent.

In particular, the independent financial agent creates the conditions for the performance of the activities of subordinate financial agents, through the training the independent financial agent organizes and the provision of various records and other documents (suitability test, adequacy test, AML-questionnaire, consent to the processing of personal data, etc.). For this purpose, the independent financial agents also create and make available information to their subordinate financial agents, for example through the intranet they have built.

In practice, especially in companies with a large network of subordinate financial agents, a back office is set up to provide "administrative service" and "legal support" to the group of entrepreneurs in question. The subordinate financial agent does not spend resources on these services.

The fact that the subordinate financial agent is under the delegated supervision of an independent financial agent allows it to operate prudently. In the conduct of financial intermediation, we characterize prudence as the avoidance of a shortfall in activity. Given the fact that the subordinate financial agent belongs to the group of sanctionable entities, a given precautionary action on the part of the independent financial agent may precede the imposition of a sanction. It follows that the subordinate financial agent also benefits from advantages of a non-material nature by virtue of the existing contractual relationship with the independent financial agent.

Financial intermediation is a business carried out for profit. This is a key motivating factor for a subordinate financial agent to terminate a contract concluded with the independent financial agent. The subordinate financial agent is concluding subsequently a new contract with a new independent financial agent.

An independent financial agent is entitled to have written contracts with several financial institutions in the relevant sector at the same time, there is a presumption that the portfolio of business partners at the new proposer will be different from the previous one.

The subordinated financial agent(s) that are integrated into the new network tend to approach clients that they have already brokered a financial services contract for in the past, during the duration of the contractual relationship with the original proposer. The practices in question generally result in the termination of the financial service contract by the client and the conclusion of a new one.

This practice may also have a negative impact on the client's assets. We believe that, with regard to the protection of clients, particularly non-professional clients, legislative intervention is necessary.

We propose the incorporation of Section 33a into the Financial Intermediation Act, which would read as follows:

Article 33a

Where a subordinate financial agent makes an offer to conclude a financial service contract to a client in the relevant sector for whom it has already carried out financial intermediation, after the conclusion of a financial service contract in the relevant sector, the subordinate financial agent shall be obliged to

- inform the client of the history of all written contracts concluded pursuant to Article 9 of this Act over the last 10 years, including the exact periods of time during which financial intermediation has been carried out for a particular independent financial agent, as well as the name, registered office/place of business, identification number of the independent financial agent,
- inform the client of the legal consequences of terminating a financial service contract in the relevant sector and concluding a new financial service contract in the relevant sector.

We consider that the range of data in question will enable the client to make an informed decision.

Consideration de lege ferenda No 4

Continuing education is a necessity that is inextricably linked to the practice of financial intermediation.

The statutory body, or at least one member of the statutory body of an independent financial agent, shall demonstrate in supervisory proceedings the successful completion of specific financial education as part of the legal institution of professional competence. In our view, the regulatory requirement in question reflects the fact that the legislator does not require financial agents to have completed a certain type of course of study.

On the contrary, this business remains open, under the legal conditions, to all those who have attained at least a secondary vocational education. The proper exercise of financial intermediation is possible only on the basis of the possession of information about the financial service to be intermediated, and the legislator therefore requires special training in the relevant sector of the financial market.

Secondary legislation, the Decree of the Ministry of Finance of the Slovak Republic No. 39/2018 Coll. on Special Financial Education for Persons Carrying out Financial Intermediation and Financial Advisory, determines in particular the scope and timing of special financial education, for a certain sector and the respective level of professional competence.

We consider the regulation in question to be desirable for persons commencing the practice of financial intermediation, irrespective of the category of financial agent in which they operate.

At the same time, it should not be overlooked that the legislation imposes an obligation on individuals to undergo specific financial training on an annual basis. Financial agents renew the relevant information annually.

This ensures a certain level of knowledge. However, in our view, the "static" definition of special financial education topic headings for the relevant sector and level of special financial education leads to repetition and stagnation in practice. From the point of view of client protection, it seems preferable for secondary legislation to determine the content of special financial education topics on an annual basis, reflecting current trends.

We therefore propose amending Article 22a Paragraph 16 and inserting a new paragraph 17 after it in the Financial Intermediation Act to read:

> (16) The content and scope of special financial education and other details of special financial education for persons who will be entered in the register of financial agents, financial advisors, financial intermediaries from another Member State in the insurance or reinsurance sector and financial intermediaries from another Member State in the field of housing loans shall be established for the first time by a generally binding legal regulation of the Ministry of Finance of the Slovak Republic.
>
> (17) The content and scope of special financial education and other details of special financial education for persons already registered in the register of financial agents, financial advisors, financial intermediaries from another Member State in the insurance or reinsurance sector and financial intermediaries from another Member State in the field of housing credit shall be established annually for the relevant calendar year by a generally binding legal regulation of the Ministry of Finance of the Slovak Republic.

It follows that the special blanket rules regulate the obligations of different categories of natural persons. They provide for special financial education of two levels. In the first, propedeutic level, we are talking about natural persons starting to carry out financial intermediation.

Natural persons, who have been registered in the register, carrying out financial intermediation as financial agents of different categories, need to have different information than persons in the above group. The educational function in relation to them would be fulfilled by specific financial education with different subject matter.

One of the key reasons for the need to implement the two-tier model of special financial education in question is the COVID-19 pandemic, which has had a lasting impact on all areas of social life. It has brought with it fundamental changes in the way financial intermediation is carried out, shifting from face-to-face contact to interaction between financial agent and client in a virtual environment.

It has highlighted the need to educate financial agents about the legal regulation of intermediation and the conclusion of distance contracts (the application of the set of legal norms in question in practice can be expected in the future, even in view of the high risk and likelihood of a next wave of the pandemic).

By determining the topics of specific financial education for the calendar year in question on an annual basis, the legislator would ensure that financial agents' knowledge would be more up-to-date, thereby also contributing to increased client protection.

References

1. Peráček, T.: E-commerce and its limits in the context of the consumer protection: the case of the Slovak Republic. Juridical Tribune **12**(1), 35–50 (2022). https://doi.org/10.24818/TBJ/2022/12/1.03
2. Aigner, M., et al.: Besonderes Verwaltungsrecht. 2. aktualisierte und erweiterte Auflage. Jan Sramek Verlag, Wien (2017)
3. Rejnuš, O.: Finanční trhy. 4. aktual. a rozšířené vydání. Grada Publishing, Praha (2014)
4. Inderst, R.: Consumer protection and the role of advice in the market for retail financial services. J. Inst. Theor. Econ. **1**, 4–21 (2011). ISSN 0932-4569
5. Chovancová, B., et al.: Finančný trh: nástroje, transakcie, inštitúcie. IURA EDITION, Bratislava (2006)
6. Law, K.K.F., Zuo, L.: How does the economy shape the financial advisory profession? Manage. Sci. **4**, 2466–2482 (2021). ISSN 1526-5501
7. Dudinská, E.: Metodika vypracovania diplomovej práce. Vydavateľstvo EKONÓM (1996)
8. Monti, M., et al.: Retail investors and financial advisors: new evidence on trust and advice taking heuristics. J. Bus. Res. **8**, 1749–1757 (2014). ISSN 0148-2963
9. Gonda, V.: Ako napísať a úspešne obhájiť diplomovú prácu. 6. prepracované a doplnené vyd. IURA EDITION, Bratislava (2012)
10. Junker, A.: Internationales Privatrecht. 2. Auflage. C. H. Beck, München (2017)
11. Kischel, U.: Rechtsvergleichung. C. H. Beck, München (2015)
12. Knapp, V.: Úvod do vědecké práce. Vědecká propedeutika. Univerzita J. E. Purkyně, Brno (1981)
13. Farquhar, J.D., Meidan, A.: Marketing Financial Services, 2nd edn. Palgrave and Macmillan, New York (2010)
14. Radvan, M., et al.: Právo kapitálového trhu. Masarykova univerzita, Brno (2010)
15. Svoboda, J., et al.: Slovník slovenského práva. 1. novodobé vydanie. Poradca podnikateľa, Žilina (2000)
16. Bakeš, M., et al.: Finanční právo. 5. upravené vydání. C. H. Beck, Praha (2009)
17. Musílek, P.: Trhy cenných papírů. 2. aktual. a rozšířené vydání. Ekopress, Praha (2011)
18. Pavlát, V., et al.: Kapitálovét rhy. 2. doplněné vydání. Professional Publishing, Praha (2005)
19. Polouček, S., et al.: Peníze, banky, finanční trhy. C. H. Beck, Praha (2009)
20. Kočišová, L., Mucha, B., Peráček, T.: The position and importance of stock exchange market and central securities depository as the inseparable part of the capital market of the Slovak

Republic. In: Bem, A., Daszyńska-Żygadło, K., Hajdíková, T., Juhász, P. (eds.) Finance and Sustainability. Springer Proceedings in Business and Economics. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-92228-7_16
21. Kohajda, M.: Finanční instituce jako poskytovatel finanční služby. In: Inovatívne formy tvorby peňažných fondov a ich prevodov: zborník príspevkov z vedeckej konferencie. Právnická fakulta Univerzity Komenského v Bratislave, Bratislava, pp. 66–73 (2018)
22. Mittelman, A., Mucha, B., Peráček, T.: The particular aspects of procurement contracts of trading in securities in the conditions of the Slovak Republic. In: Bem, A., Daszyńska-Żygadło, K., Hajdíková, T., Juhász, P. (eds.) Finance and Sustainability. Springer Proceedings in Business and Economics. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-92228-7_15
23. Gürtler, M.: Poistenie právnej ochrany. Ochrana právnych záujmov a jej postavenie na poistnom trhu. C. H. Beck, Bratislava (2018)
24. Kravecová, D.: Finančné sprostredkovanie. Ako podnikať legálne. IURIS LIBRI, Bratislava (2016)
25. Slezáková, A., et al.: Samostatný finančný agent ako dohliadaný subjekt finančného trhu. Wolters Kluwer, Bratislava (2016)
26. Winkler, M.: Delegovaný dohľad nad finančným sprostredkovaním v Slovenskej republike. In: Právo v podnikání vybraných členských států EU: sborník příspěvků k XI. ročníku mezinárodní vědecké konference. TROAS, Praha, pp. 277–286 (2019)
27. Slezáková, A., et al.: Zákon o finančnom sprostredkovaní a finančnom poradenstve. Komentár. Wolters Kluwer SR, Bratislava (2020)
28. Moloney, N.: EU Securities and Financial Markets Regulation, 3rd edn. Oxford University Press, Oxford (2014)
29. Krimphove, D., et al.: Fintechs. Rechtliche Grundlagen moderner Finanztechnologien. Schäffer-Poeschel Verlag für Wirtschaft, Steuern, Recht, Stuttgart (2019)
30. Zhou, W.: Abhilfemaβnahmen in der Fusionskontrolle und Ausgleichsmaβnahmen in der Banken-Beihilfekontrolle. Eine rechtliche und ökonomische Betrachtung. Springer Gabler, Wiesbaden (2014)
31. Slezáková, A.: Komparácia zákonných podmienok pre distribúciu doplnkového dôchodkového sporenia v SR a doplnkového penzijného sporenia v ČR. In: STUDIA IURIDICA Cassoviensia, vol. 1, pp. 85–94. ISSN 1339-3995 (2021)
32. Berisha, A., et al.: Haftpflicht-, Rechtsschutzversicherung und Versicherungsvertriebsrecht. MANZ´sche Verlags- und Universitätsbuchhandlung, Wien (2018)
33. Peráček, T.: A few remarks on the (im)perfection of the term securities: a theoretical study. Juridical Tribune **11**(2), 135–149 (2021). https://doi.org/10.24818/TBJ/2021/11/2.01
34. Škopová, V., et al.: Zákon o pojišťovacích zprostředkovatelích a samostatných likvidátorech pojistných událostí a předpisy související. Komentář. C. H. Beck, Praha (2006)
35. Hoppe, U.: Teachware für Finanzdienstleister: Entwicklung – Integration – Einsatz. DUV, Dt. Univ. Verl., Wiebaden (2000)
36. Lazar, J., et al.: Občianske právo. II. diel. Záväzkové právo. Právo duševného vlastníctva. Vydavateľstvo MANZ a Vydavateľské oddelenie Právnická fakulta UK, Bratislava (1994)
37. Karfíková, M., et al.: Pojišťovací právo. Leges, Praha (2010)
38. Valentine, J.L.: Síla MLM. Networking: podpora—marketing. Pragma, Praha (2004)
39. Clothier, P.: Multi-level marketing. 2. vyd. Pelikán, Holice (1995)
40. Števček, M., et al.: Občiansky zákonník 1. § 1–450. Komentár. C. H. Beck, Praha (2015)
41. Dvořák, J., et al.: Občanské právo hmotné 1. 2. aktualizované a doplněné vyd. Wolters Kluwer, Praha (2016)
42. Švestka, J., et al.: Občanský zákonník (§ 1-459). Komentář. C. H. Beck, Praha (2008)
43. Fekete, I.: Občiansky zákonník. Všeobecná časť. 1. zväzok. Veľký komentár. 3. aktualizované a rozšírené vyd. Eurokódex, Bratislava (2017)
44. Veterníková, M.: Vybrané kapitoly zo spotrebiteľského práva. Vydavateľstvo EKONÓM (2015)
45. Gunárová, S.: Koncept zneužitia práva v daňovo-právnych vzťahoch v podmienkach európskej únie [dizertačná práca]. Univerzita Komenského v Bratislave, Právnická fakulta, Bratislava (2015)

46. Devlin, J.F. et al.: Trust in financial services: retrospect and prospect. J. Fin. Serv. Mark. **6**, 234–245 (2015). ISSN 1479-1846
47. Fong, K.Y.L., Gallagher, D.R., Lee, A.D.: Individual investors and broker types. J. Fin. Quant. Anal. **2**, 431–451 (2014). ISSN 1756-6916
48. Fridmanskyy, R., et al.: Konstytucijno-pravovyj status urjadu v Ukrajini ta FRN: porivnjaĭno-pravovyj analiz. [1. vyd.]. Heĭvetyka, Užhorod (2014), 219 pp. ISBN 978-966-916-013-3
49. Hajnišová, E.: Registre a registratúry. In: Hospodárske právo: 1, pp. 181–242. Wolters Kluwer SR, Bratislava (2019). ISBN 978-80-571-0088-1
50. Hajnišová, E., Fekete, Á.: Entitlement to sales commissions and its maturity in cases of commercial representation under Slovak law. Obchodní právo. - Roč. **22**(3), 98–105 (2013). ISSN 1210-8278
51. Knapp, V., Gerloch, A.: Logika v právním myšlení. 3. aktualizované vyd. Eurolex Bohemia, Praha (2001)
52. Sidak, M., et al.: Investment protection: determination of legal aspects with reflecting to the innovations to ensure sustainable growth of the Slovak Republic. In: Entrepreneurship and Sustainability Issues. Entrepreneurship and Sustainability Center, Vilnius (Litva), vol. 7, no. 3, pp. 2350–2362. ISSN (Online) 2345-0282 (2020) [online]

A Comparison of the Strategies of SMEs and Large Companies in the Field of Occupational Safety

Valéry Wöll and Rozália Sulíková

Abstract The prevention of occupational accidents is not only an important factor for productivity and profitability, but also for the job satisfaction of employees in any company. Striving for a high level of occupational safety is therefore crucial, as the shortage of skilled workers has not significantly abated permanently because of the Corona crisis and preventing accidents and maintaining the working capacity of existing employees ensures the functioning of the company. Organizations use various strategies to improve occupational safety performance, but not all strategies succeed. In particular, it also shows that there are differences in the average frequency of accidents among organizations with different numbers of employees. This paper explores the question of whether small and medium-sized enterprises, in contrast to large enterprises, pursue different strategies in occupational safety and whether these different strategies have an influence on the number of occupational accidents. To answer the research questions, the authors used the methods of standardised questioning according to Reinecke, literature analysis according to Webster and Watson, deduction, comparison, and synthesis. Based on a survey of 118 companies in the Federal Republic of Germany, it was found that the strategy of small and medium-sized companies differs significantly from the strategy of large companies. The strategies in the respective size classes differ above all in the aspects of degree of organisational structure, systematics, investigation of occupational accidents and existence of continuous improvement.

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1 Introduction

In the year 2020 913,315 occupational accidents occurred in the Federal Republic of Germany [1]. This corresponds to a decrease of approx. 13.69% compared to the previous year and is most likely due in part to the government's Corona virus-related measures, as the reportable occupational accidents per 1 million hours worked only decreased by approx. 10.28% [2]. Overall, approximately 1.76 billion fewer hours were worked by workers insured under the accident insurance scheme in 2020 than in 2019 [2] and the percentage of firms regularly sending employees to the home office increased from 51% before the Corona crisis to 76% in 2020 during the partial contact and curfews imposed by the government [3]. As a result, reportable commuting accidents also fell by 18.1% and fatal commuting accidents by as much as 23.0%. Nevertheless, with an average of 27.8 lost days per accident [4] and approximate costs of 200–400€ per lost day [5], the costs of occupational accidents in 2020 for companies amounted to up to 10.16 billion euros. In addition, of course, there are the indirect costs to society for the treatment and care of the injured persons. The annual survey of the employer's insurance also shows that the number of accidents per 1,000 full workers varies greatly according to the size of the company, measured by the number of employees.

The figures in Table 1 [1, 6, 7] show that in very small companies with up to 9 employees, the accident figures are still significantly lower than the average (24.0). In companies with between 10 and 49 employees, the accident figures then rise sharply by approx. 33%, while in companies with more than 50 employees the accident figures then fall again in proportion to the size of the company. This conspicuity can also be observed in the previous years. The fact that the number of employees alone is a decisive factor for accident frequency in companies can almost be ruled out, since there is no linear relationship between the number of employees and accident frequency. It is possible that accident frequency is influenced by different strategies used in companies of different sizes. Companies with up to 9 employees can normally be very well supervised by one person due to the small management span. The increasing management span with a larger number of employees and the lack of trained hierarchies in the area of occupational safety could have an influence on the performance of the companies with regard to the prevention of occupational accidents. An excessively large span of management usually leads to an overload of instances and a lack of control and monitoring functions [8].

The results of the accident surveys by the employer's insurance thus raise the question of whether different strategies of companies of different sizes could possibly have an influence on the frequency of accidents in companies.

The research question of the publication is thus: "Do companies with different numbers of employees have different strategies with regard to the prevention of occupational accidents?".

The term strategy is currently defined in the scientific literature [9] as follows: "A strategy is a fundamental and long-term oriented behaviour of a company and relevant subdivisions towards the environment with the intention of realizing the

Table 1 Shows the accident frequency per 1,000 fulltime workers by company size over the course of the last 3 years [1, 6, 7]

Number of employees	Accident frequency per 1,000 MA/a in 2018	Accident frequency per 1,000 MA/a in 2019	Accident frequency per 1,000 employees/a in 2020
0–9	21.3	21.5	20.6
10–49	28.6	28.9	27.4
50–249	27.4	28.1	24.3
250–499	23.6	22.3	19.7
500–x	20.5	19.3	17.2

intended goals." The various aspects of the occupational safety and health (OSH) strategy are also taken up by the international standard for OSH management systems ISO 45001 [10] and serve as test points for a functioning OSH management system.

The various aspects from Table 2 [authors own creation] according to important actual standards of OSH [5, 10, 26–28] lead to the following sub-questions, the answers to which are intended to provide a picture of the different strategies of companies by size class:

- *Degree of organisational structure of occupational safety*
  - *Is there a separate department for occupational safety?*
  - *How many people are employed in this department?*
- *Degree of systematic organisation*
  - *Do the organizations maintain a certified management system?*

Table 2 Shows the different aspects of the Occupational Safety and Health strategy and their connection to the actual OSH standards

Aspects of strategy	ISO 45001	SCL	SCC
Degree of organisational structure of occupational safety	Chapters 4, 5, 6	Chapters 1.1, 3.8	Chapter 1
Degree of systematic organisation	Chapter 10	Chapters 1.1, 3.8	Chapter 1
Degree of compliance with basic documentation requirements	Chapter 7	Chapter 4.9	Chapter 2
Level of investigation of workplace accidents	Chapters 8, 10	Chapters 5.13, 5.14	Chapter 12
Structured and defined handling of deviations	Chapter 8	Chapter 1.3	Chapter 12
Use of measures to prevent deviations	Chapters 9, 10	Chapter 1.3	Chapter 12
Existence of modern measures to improve and increase the efficiency of employee instructions	Chapter 10	Chapter 2.5	Chapter 4

- *Degree of compliance with basic documentation requirements*
  - *Are the basic documents risk assessment, operating instructions and proof of instruction available at each workplace?*
  - *What documents do the organizations use for workplace risk assessment?*
- *Level of investigation of workplace accidents*
  - *What types of safety-related incidents do the organizations investigate?*
  - *How detailed do the organizations investigate workplace accidents?*
- *Structured and defined handling of deviations*
  - *How do the companies deal with deviant behaviour of employees?*
- *Use of measures to prevent deviations*
  - *What different occupational safety and health instruments do the companies use to prevent accidents?*
- *Existence of modern measures to improve and increase the efficiency of employee instructions*
  - *What media formats do companies use in relation to occupational safety?*
  - *Which digital devices do companies use in relation to occupational safety?*

The aim of the article is to analyze the different occupational health and safety strategies of companies of different sizes. Based on the analysis of the most common international OSH standards (Table 2), we developed 12 different questions to map the different aspects of OSH strategies in the survey conducted. The options for responses in the partially closed standardized survey were identified through a literature review. The derivation of the questions and answers is explained in connection with the respective question in Chap. 3.

2 Methods

The method of standardised questioning according to Reinecke [11] was chosen to answer the research questions. By means of an online survey, 118 data sets were collected over a period of 42 days. A quantitative data analysis was carried out with these 118 data sets. Data sets from the survey have already been used in part and in a different context for a scientific publication [12].

2.1 Formulation of the Questions

A literature search according to Webster and Watson [13] was used to define the aspects of the OSH strategy and to define the questions. As it was not possible to narrow down the possible answers with final certainty for all questions, the respondents were given the opportunity to indicate unknown answers by means of a free text in the "Other" section for some questions. Hybrid questions were formulated that favour possible closed answers but allow for a free response.

2.2 Provision of the Questionnaire and Response Rate

The questionnaire was sent out digitally only. The survey took place between 29 March 2021 and 10 May 2021. 1,035 people were contacted by e-mail and asked to participate in the survey. The respondents were either economically active as companies in the Federal Republic of Germany or are active as safety engineers in the nationwide network of the VDSI Association for Safety, Health and Environmental Protection at Work. In addition, the link to the survey was also shared in the online forum of the SIFA network. 861 companies and 174 experts were contacted. Of the total 1,035 respondents, 118 took part in the survey. The response rate thus corresponded to approx. 11.4%. Since 72.8% of the 118 participants in the survey stated that they were safety engineers, it is assumed that a large proportion of the participants were generated via the networks and that the response rate was significantly lower due to the letters to the companies.

2.3 Narrowing the Sample to Ensure Representativeness

In order to represent the population of relevant characteristics as real as possible, the main task is a good delimitation of the sample [14]. Before the actual research questions, questions were asked in the questionnaire to narrow down the relevant characteristics of the sample. The selection of the characteristics is based on the characteristics used in the categorisation by the employers' liability insurance associations in the Federal Republic of Germany [15] and the essential conditions for a survey according to Reineke [11].

The following characteristics were considered relevant for narrowing down the sample:

- *Branch of the company.*
- *Position of the respondent in the company.*

Table 3 Shows the companies surveyed sorted by industry according to DESTATIS [16] and accident frequencies according to the survey of the employers' liability insurance association in 2020 [1]

Sector according to DESTATIS	Accident frequency in the sector/1,000 MA/a	Ø Share of companies in the FRG	Share of companies in the survey	Accident frequency * Ø share of companies in Germany	Accident frequency * companies surveyed
Manufacturing industry	25.3	9	48.30	227.70	1221.99
Construction	55.5	11	8.47	610.50	470.09
Trade	19.1	17	0.85	324.70	16.24
Transport	35.7	3	0.26	107.10	9.28
Hotels and restaurants	23.2	9	0.85	208.80	19.72
Information-communication technologies	Unknown (Ø FRG assumed)	4	0	87.20	0.00
Other services	26.3	49	41.27	1288.70	1085.40
Average FRG	21.8	100	100	407.81	403.24

2.4 Sector

The sector of the companies surveyed is considered relevant for narrowing down the sample, as the accident frequencies of the different sectors differ greatly. The DGUV also considers the industry affiliation of a company to be so relevant for calculating the required efforts in occupational safety and health that the hours to be spent by an OSH professional in the company depend on the industry affiliation or the WZ code of the company's purpose [15]. In a mining company, for example, the occupational safety specialist and company physician must work 2.5 h per employee per year, whereas in a purely office-based company only 0.5 h per employee must be spent. It must therefore be assumed that companies in different sectors develop different levels of OSH organisation. According to the DETSATIS classification [16], the breakdown of the respondents' industries is as follows (Table 3).

In the calculated comparison of the accident frequency between the average in the FRG and the average of the surveyed companies, only a deviation of approx. 1.12% in the accident frequency can be determined. It is therefore assumed that the influence of the distribution of the industries in the study has a minor impact on the result of the analysis. From the author's point of view, it is not necessary to narrow down the population based on the industry of the respondents.

Table 4 Shows the position of the persons who answered the questionnaire

Position	Number	Share in the survey (%)
CEO	9	7.63
Safety Engineer	71	60.17
Manager	12	10.17
Employee	18	15.25
Other	8	6.78
Total	118	100

2.5 Responded Answers

The responding respondents were mainly safety engineers with 60.17%. It is therefore assumed that the network survey generated above-average response behaviour in contrast to the invitations to participate in the survey, which were sent directly to companies.

Due to the special training of a large part of the respondents and the professional expertise of the answerers, a good data basis can be assumed. The distribution of the answers according to the positions of the respondents in the company were received according to Table 4.

In the author's view, it is not necessary to narrow down the population on the basis of the respondents' positions because no negative influence on the statement is assumed due to the different positions.

2.6 Other Sources of Error

According to Reineke [11], 4 conditions are essential for the successful implementation of a survey:

- *The existence of a common language.*
- *The cooperation of the respondent.*
- *The recognition of the importance of the respondent's answer.*
- *The existence of a "norm of sincerity" among respondents.*

The very low use of the alternative open response options of about 9% on average in the survey confirms the use of a common language in the survey. According to Reineke [11], the cooperation of the respondents is based in particular on the respondent's interest in the topic and willingness to support the scientific work. Since all respondents participated in the survey voluntarily and participation was anonymous, cooperation can be assumed. Since the respondents took the appropriate amount of time for the survey, it is assumed that an importance was acknowledged. A high level of sincerity is assumed, as no personally sensitive questions were asked in the survey and the survey was anonymous.

2.7 Sample Size and Margin of Error

A delimitation does not take place. This results in a population size of 3,374,583 companies in the Federal Republic of Germany [16]. The confidence level was chosen as standard at 95%. With 118 representative responses from the sample, a margin of error of approx. 9% was thus achieved. All results from the corresponding survey thus lie within an error range of ±9% with a probability of 95%.

2.8 Utility Analysis

The evaluation of the questions is done by means of a utility analysis according to Thormählen [17]. The utility analysis is used because it has the advantage that the concept reduces the danger of forgetting aspects in the evaluation. Furthermore, there is a certain compulsion for objectivity and systematisation [17].

3 Results of the Literature Review and the Survey

Question 1—Is there a separate department for occupational safety?

The question is intended to find out whether the organisation considers the field of occupational safety to be so strategically relevant that it creates a separate organisational unit for the field. This means that the organisation firstly sees the organisation of occupational safety as an important task and secondly makes defined resources available to occupational safety.

- *Formulated question 1: Does your company have its own occupational safety department?*
- *Conditions: Only one answer is possible.*

The answers to the question can be found in Table 5.

Table 5 Shows the results of question no. 1

Number of employees	Yes (%)	No (%)
1–10	0.00	100.00
11–50	11.11	88.89
51–300	60.71	39.29
301–1,000	51.85	48.15
>1,000	83.33	16.67
>10,000	100.00	0.00
Average	55.93	44.07

The evaluation shows that only companies with more than 50 employees significantly start to establish their own departments for occupational safety. In companies with more than 1,000 employees, however, an occupational safety department already exists in more than 83% of the companies. The definition of fixed structures and the associated planned provision of resources for occupational safety is evaluated positively.

Question 2—How many people do you employ full-time in occupational safety?

The question aims to find out how many experts companies employ on average for occupational safety. It is assumed that experts who are employed full-time are not subject to role conflicts and can work more efficiently because they can concentrate on the topic of occupational safety. Thus, the decision to employ full-time workers in the field of occupational safety is a positive one.

- *Formulated question 2: How many people are employed full-time in occupational safety in your company?*
- *Conditions: Only one answer is possible.*

The answers to the question can be found in the following table.

The Table 6 shows that only companies with 50–300 employees begin to employ safety specialists full-time. This would also correlate with the supervision key of the statutory accident insurances [15]. For companies in the medium risk group, the supervision key specifies 1 full-time safety specialist for approx. 1,600 employees [15]. The employment of as many full-time employees as possible is viewed positively.

Question 3—Do you maintain a certified occupational health and safety management system?

The question is intended to find out whether the company has demonstrably adopted a systematic approach to improving the health and safety of its employees.

- *Formulated question 3: Do you maintain a certified occupational health and safety management system?*
- *Conditions: Only one answer is possible.*

Table 6 Shows the results of question no. 2

Number of employees	None (%)	<1 (%)	1 (%)	2 (%)	3 (%)	4 (%)	≥5 (%)	Average full time safetys
1–10	25.00	75.00	0	0.00	0.00	0.00	0.00	0.00
11–50	16.67	77.78	5.56	0.00	0.00	0.00	0.00	0.06
51–300	0.00	64.28	28.57	7.14	0.00	0.00	0.00	0.43
301–1,000	14.81	25.93	33.33	7.41	7.41	0.00	7.41	1.19
>1,000	3.33	3.33	3.33	6.67	10.00	23.33	50.00	3.90
>10,000	0.00	0.00	0.00	0.00	0.00	0.00	100	5.00

Table 7 Shows the results of question no. 3

Number of employees	Yes (%)	No (%)
1–10	12.50	87.50
11–50	16.67	83.33
51–300	21.43	78.57
301–1,000	51.85	48.15
>1,000	70.00	30.00
>10,000	85.71	14.29
Average	43.03	56.97

The answers to the question can be found in the following Table 7.

The answer shows that in small and medium-sized companies with up to 300 employees, only up to 20% of the companies operate a certified OSH management system. In companies with more than 300 employees, already more than 50% of the companies operate such a system. In large companies with more than 10,000 employees, more than 85% of the companies maintain a corresponding certificate. The proof of maintaining an OSH management system is evaluated positively.

Question 4—Which documents are consistently available at every workplace in your company?

The question aims to find out whether the companies implement the basic tasks of occupational safety and health. The question examines whether the most important requirements of the Occupational Health and Safety Act [18] and the Ordinance on Industrial Safety and Health [19] are fulfilled.

- *Formulated question 4: Which of the following documents are consistently present in the company at each workplace?*
- *Conditions: Multiple answers are possible.*

The answers to the question can be found in the following table.

The results of Table 8 show that the documentation obligation is better developed in the very small and very large enterprises than in the medium-sized enterprises with 301–1,000 employees. Fulfilment of the documentation obligations is rated positively accordingly.

Question 5—What documents do organisations use for workplace risk assessment?

The question is intended to find out whether companies actively create templates and working documents themselves, or whether they use templates from other creators. Creating documents oneself is seen as dealing with the content of the topic and is thus evaluated positively.

- *Formulated question 5: What templates do you use to assess risks in the workplace?*
- *Conditions: Multiple answers are possible.*

Table 8 Shows the results of question no. 4

Number of employees	Risk assessment (%)	Safety operation instructions (%)	Proof of instruction (%)	Average compliance with legal requirements (%)
1–10	87.50	87.50	75.00	83.33
11–50	75.00	87.50	93.75	85.42
51–300	75.00	92.86	67.86	78.57
301–1,000	57.69	88.46	65.38	70.51
>1,000	86.21	89.66	75.86	83.91
>10,000	100.00	100.00	85.71	95.24

The answers to the question can be found in the following Table 9.

The results of question 5 show that the degree of use of independently created documents increases with the number of employees. Only the group with 301–1,000 employees falls out of the steady proportional increase here.

Question 6—What types of security incidents do companies investigate?

The question aims to find out to what degree of detail companies investigate accidents of their employees. A good analysis of accidents is a prerequisite for the introduction of appropriate preventive measures. It is assumed that companies that investigate all accidents in detail are also more successful in preventing accidents.

- *Formulated question 6: What events do you investigate in your company?*
- *Conditions: Multiple answers are possible.*

The answers to the question can be found in the following Table 10.

The results show that companies with fewer than 300 employees investigate accidents with injury without loss of working hours to a disproportionately low extent. Since an investigation by the employers' liability insurance association is required for accidents with >3 days of absence, it is not surprising that the proportion of

Table 9 Shows the results of question no. 5

Number of employees	Templates of employer's insurance (%)	Different documents as needed (%)	Informal documents (%)	Other (%)	Own standards (%)
1–10	25.00	62.50	12.50	12.50	50.00
11–50	29.41	23.53	11.76	0.00	58.82
51–300	42.86	25.00	0.00	0.00	60.71
301–1,000	44.44	74.07	7.41	3.70	51.85
>1,000	43.33	43.33	10.00	3.33	76.67
>10,000	28.57	57.14	14.29	14.29	71.43

Mentioned under other: software, supplemented documents from others

Table 10 Shows the results of question no. 6

Number of employees	Accidents with >3 days absence (%)	Accidents with 1 day absence (%)	Accidents with injury (%)	Near accidents (%)	Insecure situations (%)	Other (%)
1–10	75.00	37.50	37.50	25.00	25.00	25.00
11–50	76.47	41.18	29.41	11.76	17.65	5.88
51–300	82.14	75.00	75.00	46.43	35.71	0.00
301–1,000	74.07	66.67	66.67	44.44	48.15	3.70
>1,000	73.33	73.33	73.33	56.67	36.67	3.33
>10,000	85.71	85.71	85.71	85.71	71.43	0

Mentioned under other: accidents with the same cause, events with a high hazard potential

companies that comply with this obligation is very high [20]. The investigation of all accidents with injuries is considered positive.

Question 7—What causes do companies distinguish when investigating occupational accidents?

The question is intended to find out to what degree of detail companies investigate accidents of their employees. As in question 6, it is rated positively if companies deal with accidents more intensively and the level of detail of accident investigation is higher. Here, it is again specifically evaluated whether the companies operate a standardised recording of accident causes according to the TOP principle. The principle is considered the only principle for the standardised recording of accident causes in occupational safety and health [21].

- *Formulated question 7: What causes do you distinguish when investigating accidents at work?*
- *Conditions: Multiple answers are possible.*

The answers to the question can be found in the following Table 11.

The results of the question show that companies with 11–50 employees have the lowest rate of standardised accident investigation. From 50 employees, the rate of standardised accident investigation rises sharply. A standardised recording of accident causes is rated positively.

Question 8—How detailed do companies investigate the cause of human error accidents?

The question aims to find out whether companies are addressing the main cause of accidents in German companies. Studies have shown that human error is the cause of an occupational accident in approx. 76–96% of all cases [21].

- *Formulated question 8: What types of human error do you record in accident analysis?*
- *Conditions: Multiple answers are possible.*

Table 11 Shows the results of question no. 7

Number of employees	We don't record causes of accidents (%)	Technical failures (%)	Organisational failures (%)	Human mis-conduct (%)	Other (%)	Companies that identify the causes (%)
1–10	37.50	50.00	50.00	50.00	25.00	62.50
11–50	55.56	44.44	38.89	44.44	5.56	44.44
51–300	32.14	67.86	67.86	64.29	3.57	67.86
301–1,000	18.52	70.37	70.37	81.48	3.70	81.48
>1,000	10.00	83.33	83.33	86.67	10.00	90.00
>10,000	0.00	100.00	100.00	85.71	28.57	100.00

Mentioned under others: Unsafe situations, method, material, combinations, environmental influences

The answers to the question can be found in the following Table 12.

The results show that the likelihood of companies investigating human error more closely increases proportionally with the number of employees. The group of companies with 301–1,000 employees also falls slightly behind.

Question 9—What are the consequences of irregular behaviour in companies?

The question is to find out whether companies use targeted consequences to change the behaviour of deviant employees. Scientific studies have shown that the targeted use of positive and negative consequences promotes the safety-conscious behaviour of employees [22].

- *Formulated question 9: What are the consequences of irregular unsafe behaviour in your company?*

Table 12 Shows the results of question no. 8

Number of employees	None of them (%)	Unconscious unintentional errors (%)	Consious unintentional errors (%)	Consious intentional errors (%)	Other (%)	Companies that investigate human error (%)
1–10	75.00	25.00	25.00	25.00	0.00	25.00
11–50	61.11	38.89	22.22	27.78	0.00	38.89
51–300	35.71	64.29	42.86	21.43	3.57	64.29
301–1,000	41.67	45.83	37.50	29.17	8.33	58.33
>1,000	16.67	80.00	63.33	40.00	13.33	83.33
>10,000	28.57	57.14	71.43	57.14	14.29	71.43

Mentioned under others: physical fitness, ignorance, third-party fault, lack of concentration, recklessness, tripping, falling, bicycle accidents

- *Conditions: Multiple answers are possible.*

The answers to the question can be found in the following Table 13.

The results show that the number of employees has no significant influence on the initiation of measures after deviant behaviour of employees. Acting on deviant behaviour is seen as a positive contribution to the company's strategy.

Question 10—What methods do companies use to prevent accidents at work?

The question aims to find out which mix of different methods companies use to prevent accidents at work and to fulfil their legal obligations and whether the size of the company has an influence on the selection of the different methods. It will also be examined whether the number of employees leads companies to use more different methods for instructing their employees and thus design a more efficient transfer of knowledge [23]. In addition, it will be examined whether the companies fulfil their obligation to monitor the implementation of the measures according to the occupational safety act [18].

- *Formulated question 10: What OSH tools do you use to improve safety in your company?*
- *Conditions: Multiple answers are possible.*

The answers to the question can be found in the following Table 14.

The results show that in companies with more than 50 employees the number of methods used increases significantly. The use of different methods is evaluated positively.

Question 11—What media devices do companies use in the area of occupational safety?

The question aims to find out which companies have adopted the current mega-trend of digitalisation. Since it is assumed that digitalisation brings with it an increase in efficiency in company processes [25], the implementation of digitalisation measures is seen as a sign of continuous improvement in occupational safety and health.

- *Formulated question 11: Which media devices do you use in relation to occupational safety?*
- *Conditions: Multiple answers are possible.*

The answers to the question can be found in the following Table 15.

The results show that the use of different media terminals increases significantly in companies with more than 50 employees. The use of different media devices is considered positive.

Question 12—What media formats do companies use in the area of occupational safety?

The question is to find out which media formats the companies use, as it is assumed that the mix of different end devices increases the learning effect [24, 25] and the use can be seen as the implementation of a digitalisation strategy.

Table 13 Shows the results of question no. 9

Number of employees	No consequences (%)	Negative feedback by manager (%)	Negative feedback by higher management (%)	Official documented warning (%)	Unpaid leave of absence (%)	Termination (%)	Other (%)	Companies taking action (%)
1–10	25.00	62.50	0.00	37.50	0.00	12.50	37.50	75.00
11–50	22.22	61.11	22.22	27.78	0.00	16.67	16.67	77.78
51–300	14.29	85.71	50.00	17.86	3.57	3.57	14.29	85.71
301–1,000	28.00	56.00	40.00	24.00	4.00	0.00	12.00	72.00
>1,000	33.33	66.67	33.33	30.00	6.67	13.33	16.67	66.67
>10,000	14.29	71.43	42.86	28.57	14.29	28.57	42.86	85.71

Mentioned under others: safety talks, staff talks, training, discussion, instruction, additional instruction, individual consequences, different levels of escalation

Table 14 Shows the results of question no. 10 in %

Number of employees	Instruction without test	Instruction directly with test	Training of employees	Online instruction without test	Online instruction with test	Observation of the employees	Self-observation of employees	Promotion in relation with safe behaviour	Internal Audits	External Audits	Other	Average number of methods used
1–10	75.0	25.0	25.0	12.5	12.5	37.5	12.5	12.5	25.0	25.0	25.0	2.9
11–50	72.2	27.7	44.4	5.5	11.1	33.3	16.6	5.5	22.2	27.7	0.0	2.7
51–300	78.5	25.0	60.7	10.7	10.7	39.2	17.8	10.7	53.5	32.1	0.0	3.4
301–1,000	73.0	38.4	69.2	15.3	42.3	53.8	15.3	7.6	76.9	38.4	3.8	4.3
>1,000	90.0	46.6	76.6	46.6	53.3	63.3	36.6	6.6	76.6	56.6	3.3	5.6
>10,000	85.7	42.8	85.7	42.8	71.4	42.8	14.2	28.5	85.7	85.7	14.2	6.0

Table 15 Shows the results of question no. 11

Number of employees	None (%)	Desktop PC (%)	Laptop (%)	Tablet (%)	Smartphone (%)	VR Glasses (%)	Other (%)	Ø Number of devices
1–10	25.00	62.50	0.00	37.50	0.00	12.50	37.50	1.50
11–50	22.22	61.11	22.22	27.78	0.00	16.67	16.67	1.33
51–300	14.29	85.71	50.00	17.86	3.57	3.57	14.29	1.54
301–1,000	28.00	56.00	40.00	24.00	4.00	0.00	12.00	2.31
>1,000	33.33	66.67	33.33	30.00	6.67	13.33	16.67	2.43
>10,000	14.29	71.43	42.86	28.57	14.29	28.57	42.86	3.29

Mentioned among others: PDF hand-out, online training, flip chart, presentation with visual object

Table 16 Shows the results of question no. 12

Number of employees	None (%)	Paper printout (%)	Power point (%)	Video films (%)	Virtual reality (%)	Argumented reality (%)	Other (%)	Ø Number of formats
1–10	25.00	37.50	50.00	50.00	12.50	0.00	12.50	1.63
11–50	5.56	44.44	77.78	33.33	0.00	5.56	5.56	1.67
51–300	0.00	50.00	92.86	75.00	0.00	0.00	3.57	2.21
301–1,000	0.00	76.92	92.31	65.38	7.69	11.54	3.85	2.58
>1,000	0.00	60.00	100	93.33	6.67	6.67	10.00	2.77
>10,000	0.00	57.14	100	85.71	14.29	14.29	14.29	2.86

Mentioned under others: PDF hand-out, online training, flip chart, presentation with visual object

- *Formulated question 12: What media formats do you use in safety briefings for your employees?*
- *Conditions: Multiple answers are possible.*

The answers to the question can be found in the following table.

The results from Table 16 show that the use of different media formats increases continuously with the number of employees. The use of different media formats is considered positive.

4 Conclusion

The results of the individual evaluations were transferred into a rating system that takes the best rating as 10 and the worst rating as 0. Accordingly, the values were converted proportionally into a system of 10. The individual questions are added up

and thus represent an evaluation of all aspects of the companies' strategy in the area of occupational safety and health. Table 17 [authors own creation] can thus serve as a utility value analysis of the different strategies of the companies in the area of occupational safety.

In order to be able to better interpret the results, the achieved utility value totals of the companies by size class were put into relation with the average number of employees of the companies in Fig. 1 [authors own creation].

One can clearly see that there is a gradation between micro enterprises with up to 50 employees, enterprises between 51 and 1,000 employees and large enterprises with more than 10,000 employees. The differences in the 3 gradations are then smaller. If we look at the values of the first two size classes, we see that the OSH strategy of micro-enterprises with up to 10 employees hardly differs from the strategy of enterprises with up to 50 employees. The individual questions and aspects are also almost identical in groups 1 and 2. Since the effort of OSH management in a company with 50 employees is likely to be significantly higher than in a company with 10 employees, but the groups pursue the same strategy, it is not surprising that the micro-enterprises with up to 10 employees obviously succeed better in preventing accidents than companies with 11–50 employees (Table 1). This is also indicated by the fact that the companies surveyed only begin to create their own organisational units for occupational safety and health in size category 3 with more than 50 employees and thus provide defined resources and presumably also formulate corresponding goals. Here, the number of companies that state that they investigate all accidents with injuries in the company also increases by leaps and bounds from approx. 30% to approx. 75%. The jump between class 2 and 3 is also due to the fact that 23% more companies in class 3 record accidents in a standardised manner and approx. 25% more companies in class 3 deal with human error as a cause of accidents. In addition, about 19% of class 3 companies, in contrast to companies with less than 50 employees, use more different media formats.

to confront their employees with the topic of occupational safety and health.

In summary, the characteristics of the strategy of class 1 (1–10 employees) and class 2 (11–50 employees) companies are as follows:

- *Low degree of structural organisation of occupational health and safety.*
- *Low degree of systematic organisation.*
- *Good fulfilment of documentation requirements.*
- *Low degree of investigation of occupational accidents.*
- *Well structured and defined handling of deviations.*
- *Medium degree of use of measures to prevent deviations.*
- *Low degree of existence of modern measures to improve and increase the efficiency of staff Instruction.*

In summary, the characteristics of the strategy of class 3 (>50 employees) and class 4 (>300–1,000 employees) companies are as follows:

- *Medium degree of structural organisation of occupational health and safety.*
- *Low degree of systematic organisation.*

Table 17 Shows the utility value analysis of the OSH strategies of the companies according to size classes

Number of employees	Organisation unit for OSH	Average full time safetys	Certified OSH system	Average compliance with legal requirements	Using own standards for risk analysis	Companys which in-vestigate all accidents	Companies that target the causes	Companys which in-vestigate human error	Companies that act in case of infringements	Number of used OSH methods	Number of used media devices	Number of used media formats	Total score of size-classes
1–10	0	0	1.2	8.3	5	3.7	6.2	2.5	7.5	4.8	4.5	5.7	49.67
11–50	1.1	0.1	1.6	8.5	5.8	2.9	4.4	3.9	7.8	4.5	4.0	5.8	50.76
51–300	6.0	0.8	2.1	7.9	6.0	7.5	6.7	6.4	8.6	5.6	4.6	7.7	70.36
−1,000	5.1	2.0	5.1	7.1	5.1	6.6	8.1	5.8	7.2	7.1	7.0	9.0	76.04
>1,000	8.3	7.4	7	8.4	7.6	7.3	9	8.3	6.7	9.3	7.3	9.6	96.93
>10,000	10	10	8.5	9.5	7.1	8.5	10	7.1	8.6	10	10	10	109.5

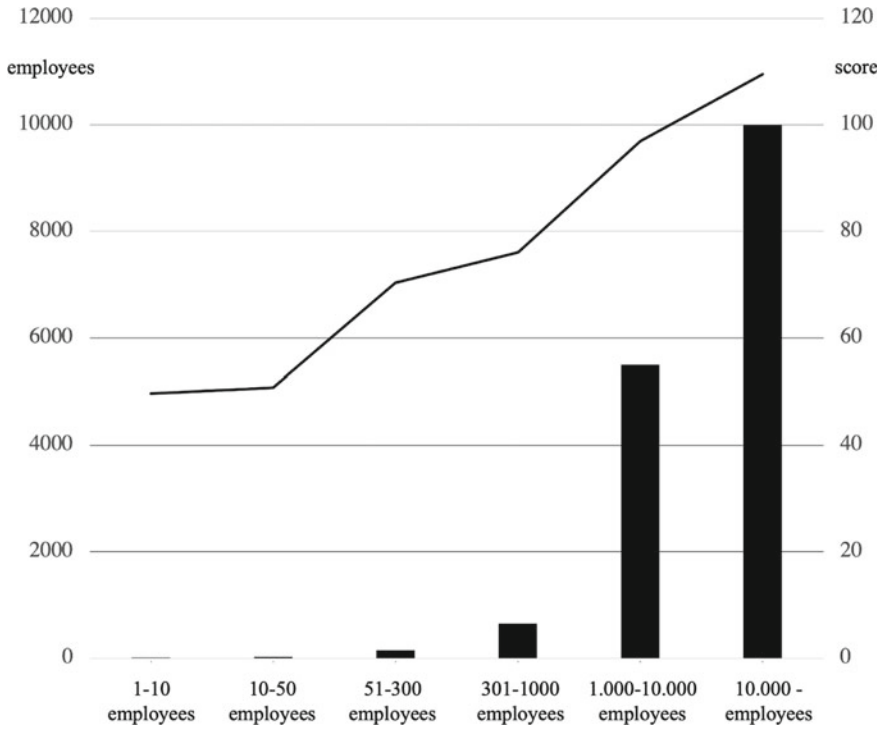

Fig. 1 Utility value analysis of the occupational safety and health strategies of the companies according to size classes in graphical representation

- *Good fulfilment of documentation requirements*
- *Average degree of investigation of occupational accidents.*
- *Well structured and defined handling of deviations*
- *Average degree of use of measures to prevent deviations.*
- *Medium degree of existence of modern measures to improve and increase efficiency of employees Instruction.*

In summary, the characteristics of the strategy of companies class 5 (>1,000 employees) and 6 (>10,000 employees) are as follows:

- Very good degree of structural organisation of occupational health and safety.
- Very good degree of systematic organisation.
- Very good fulfilment of documentation requirements.
- Good degree of investigation of occupational accidents.
- Well-structured and defined handling of deviations.
- Very good degree of use of measures to prevent deviations.
- Very good degree of existence of modern measures to improve and increase the efficiency of staff Instruction.

In conclusion, according to Table 18 [authors own creation], it can be said that small and medium-sized enterprises pursue a different strategy for implementing the assurance of occupational health and safety than large enterprises. In particular, companies with up to 50 employees build fewer structures, investigate occupational accidents less systematically and are less active with regard to modern improvement measures. In the author's opinion, however, the difference has little effect on micro-enterprises with up to 10 employees, because these enterprises are very manageable due to their small management span and obviously record fewer accidents even with a less optimal strategy. A decisive reason for the unequal strategic positioning of the companies could be a lack of occupational safety specialists, since companies in most sectors with up to 50 employees do not have to employ a trained expert in the field of occupational safety [15]. In these companies, the entrepreneur himself can provide the OSH expertise. It is of course up to the entrepreneur how much room he leaves for occupational safety in his role. There is no obligation for the entrepreneur to provide a certain amount of time for OSH. The authors believe that a significant improvement in occupational safety in companies with 11–50 employees could be achieved through the mandatory appointment of an occupational safety specialist with a defined minimum deployment time per employee. The authors recommend that the supervision time of companies with 10–50 employees by specialists in the field of occupational safety be set at 0.5–2.5 h per employee per year, depending on the industry and accident frequency, analogous to the DGUV V2 regulation [15]. Scientific monitoring of this measure with subsequent evaluation of the accident figures could provide certainty as to whether the corresponding measure is successful.

Table 18 Shows the assessed aspects of the companies' OSH strategies according to the 3 summarised size classes

Summarised size classes	Degree of organisational structure	Degree of systematics	Fulfilment of the documentation obligation	Degree of investigation of occupational accidents	Dealing with deviations	Use of measures	Existence of improvement measures
1–50 employees	–	–	+	–	+	o	–
>50 employees	o	–	+	o	+	o	o
>1,000 employees	+	+	+	+	+	+	+

References

1. DGUV: Arbeitsunfallgeschehen 2020. DGUV, Berlin (2021)
2. DGUV: Zahlen und Fakten 2020. Retrieved 09 December 2021 from https://www.dguv.de/de/zahlen-fakten/au-wu-geschehen/au-1mio-stunden/index.jsp. DGUV, Berlin (2021)
3. Demmelhuber, K. et al.: Homeoffice vor und nach Corona: Auswirkungen und Geschlechterbetroffenheit, ifo Schnelldienst Digital, vol. 1, Iss. 14. ifo Institut - Leibniz-Institut für Wirtschaftsforschung an der Universität München, München (2020)
4. Techniker Krankenkasse: Gesundheitsreport 2020. Techniker Krankenkasse, Hamburg (2020)
5. BAUA: Mit Sicherheit mehr Gewinn—Wirtschaftlichkeit von Gesundheit und Sicherheit bei der Arbeit. BAUA, Berlin (2017)
6. DGUV: Arbeitsunfallgeschehen 2019. DGUV, Berlin, Germany (2020)
7. DGUV: Arbeitsunfallgeschehen 2018. DGUV, Berlin, Germany (2019)
8. Lamers, A.: Grundbegriffe der Betriebswirtschaftslehre. In: Public Management, p. 92. Springer Gabler, Wiesbaden (2018). https://doi.org/10.1007/978-3-658-21807-2_2
9. Schuh, G., et al.: Strategie und Management produzierender Unternehmen, p. 66. Springer, Berlin Heidelberg (2011)
10. ISO: ISO 45001:2018. Beuth Verlag GmbH, Berlin (2018)
11. Baur, N., Blasius, J. (eds.): Handbuch Methoden der empirischen Sozialforschung, Mixed Methods, S.601. Springer Fachmedien, Wiesbaden, Germany (2014)
12. Wöll, V., Sulíková, R.: Current usage of models and methods to prevent unsafe behaviour of employees in industrial companies. In: Developments in Information & Knowledge Management for Business Applications. Studies in Systems, Decision and Control, vol. 420. Springer, Cham (2022). https://doi.org/10.1007/978-3-030-95813-8_24
13. Webster, J., Watson, R.: Analysing the past to prepare for the future: writing a literature review. MIS Q. **26**(2), 13–24. MIS Research Centre, Minneapolis, USA (2002)
14. Friedrichs, J.: Methoden empirischer Sozialforschung, p. 243. VS Verlag für Sozialwissenschaften, Wiesbaden (1990)
15. DGUV: DGUV V 2. DGUV, Berlin (2009)
16. DESTATIS: Beschäftigtengrößenklassen nach Destatis, Abruf am 10.12.2021, Abgerufen von: https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Unternehmen/Unternehmensregister/_inhalt.html
17. Thormählen, T.: Der Nutzwert der Nutzwertanalyse, Vol. 57, Iss. 12; pp. 638–644. Verlag Weltarchiv, Hamburg (1977)
18. Bundesregierung: Arbeitsschutzgesetz. Bundesregierung, Berlin, Germany (2020)
19. Bundesregierung.: Betriebssicherheitsverordnung BetrSichV. Bundesregierung, Berlin, Germany (2015)
20. Bundesregierung: Das Siebte Buch Sozialgesetzbuch SGB VII. Bundesregierung, Berlin, Germany (2020)
21. Wöll, V., Sulíková, R.: How to Prevent Unsafe Behaviour of Employees? Developments in Information & Knowledge Management for Business Applications, pp. 499–528. Springer International Publishing (2022). https://doi.org/10.1007/978-3-030-77916-0_16
22. Bördlein, C.: Verhaltensorientierte Arbeitssicherheit—Behavior Based Safety (BBS), 2nd edn. Erich Schmidt Verlag, Berlin, Germany (2015)
23. Meyer, N.: E-learning vs. blended learning: was bevorzugen Studierende? Welche Methode eignet sich besser zum Lernen?. Brandenburgischen Technischen Universität Cottbus Senftenberg, Cottbus (2016)

24. Poniszewska-Maranda, A., Kaczmarek, D., Kryvinska, N., Xhafa, F.: Studying usability of AI in the IoT systems/paradigm through embedding NN techniques into mobile smart service system. Computing **101**(11), 1661–1685, (2019). https://doi.org/10.1007/s00607-018-0680-z
25. Knefz-Reichnmann, A. et. al.: Effizienzsteigerung durch Digitalisierung in Kleinstunternehmen im Rechnungswesen, p. 10. Fachhochschule der Wirtschaft, Graz (2021)
26. Burstedde et al.: Fachkräftemangel bei Hochqualifizierten wieder über Vor-Corona-Niveau, IW-Kurzbericht, No. 39/2021, Institut der deutschen Wirtschaft (IW), Köln (2021)
27. DGMK: SCC Dok 006. DGMK Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V., Hamburg (2011)
28. NEN.: Zertifizierungsschema zur Safety Culture Ladder. NEN, Delft (2017)

Digital Supply Chain Implementation in the Food Industry: An Interpretive Structural Modeling Approach

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Abstract The digital supply chain is a new approach to rapid change and the emergence and application of new technologies. This approach helps to integrate chain activities and meet the demands and needs of customers. Implementing this approach in the food industry needs special features and requirements that this research identifies and models using an interpretive structural modeling approach. The results of this study showed that the criteria of technology infrastructure, organizational leadership and organizational culture are considered as the basic criteria for implementing the digital supply chain. At the next level, there are employee participation, strategic alignment and staff training and development. At the third level, there are technological awareness and project management system. At the second level, there are data standardization, technological products and technology maturity, and at the first level, there are data security, technology trust, technology compatibility and technology communications. MICMAC analysis also showed that two criteria of technological awareness and project management system are key criteria in the implementation of digital supply chain in the food industry.

Keywords Supply Chain · Digital Supply Chain Management · Interpretive Structural Modeling · MICMAC

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1 Introduction

Increasing competition in the new era and increasing the speed of service has caused organizations to have many initiatives and innovations to satisfy customers. In the new age of business, speed is a very important factor for success due to the shortening of the product life cycle. Potential customers want faster delivery of new products and services, according to their needs and expectations. Digitalization and the emergence of new technologies allow companies to quickly become aware of the demands and expectations of customers, and take action to meet them.

Digitalization changes the economic processes, business models and activities of companies; And this affects competition between companies, cooperation in the supply and production chain, and the provision of smart products and services [1]. Digitization means the use of digital data and digital technologies not only to improve processes, functions and activities, but also to change processes to achieve a particular competitive advantage. Digitalization increases revenue streams and creates new business opportunities [2].

In today's competitive market, where supply chains and production logistics processes are an important part of companies' day-to-day operations and crucial to economic development, they are also moving towards digitalization [3]. Supply chain is a set of interconnected and coordinated activities of marketing, sales, product design, inventory management, finance and information technology [4]. The use of advanced technologies in the Industrial Revolution 4, including the Internet of Things, blockchain, machine learning, artificial intelligence, predictive analytics, etc., to digitize these activities and processes, is emphasized in the digital supply chain [5].

Digital supply chain is the development of information systems and the adoption of innovative technologies, which strengthens the integrity and agility of the supply chain and thus improves customer service and sustainable performance of the organization [6]. The Industrial Revolution 4 and the pervasive demand for digital technologies are gradually increasing, making the implementation of the digital supply chain all the more necessary [7]. The digital supply chain has emerged as a result of technological advancement, complexity and dynamism of today's competitive market, and its most obvious advantages are the integration of the physical supply chain with digital technology, performing activities at the right time, optimizing organizational performance by improving accountability, robustness and flexibility [8].

To achieve a privileged position or maintain the current position, managers must seek to reduce costs, increase cooperation between companies and make them more agile, to make better use of new technology capabilities. In response to recent supply chain concerns, digital supply chains have been introduced. This approach is a powerful alternative to strengthening traditional supply chains whose main function is not very different from each other but helps to improve chain performance [9]. Digital supply chains can track and complement the processes of sourcing, turning materials into products, distributing products, and then selling products through automated digital processes that are more efficient. Digital supply chains can help more

accurately predict demand by applying Bayesian networking and machine learning approaches and discovering and modeling complex relationships between variables that affect demand [10]. An effective digital supply chain helps organizations adapt to changes in demand [11].

Organizations are looking for digital supply chains with the goal of increasing revenue, improving decision-making, and streamlining processes, but in practice, they face various challenges when they begin to digitize their supply chain. The lack of standard implementation guidelines and the ambiguity of the main factors in its implementation have led to the failure of many organizations in the implementation of digital supply chain [7]. Therefore, this study aims to design a digital supply chain implementation model and provide solutions to help organizations in the food industry.

2 Theoretical and Conceptual Background

2.1 Digital Supply Chain

Today, the emergence and application of transformational technologies such as the Internet of Things, artificial intelligence and digitalization has greatly influenced the performance of organizations. Digitization creates a huge change in the most important social elements, such as growth and stability, prosperity and equality, security and democracy in a way that it develops interactions between people, organizations and objects and improves the performance of organizations by collecting, interpreting, applying and developing large volumes of data [12]. Digital transformation is the process of using digital technologies for fundamental change and shows how a company uses these technologies to create value and interact with customers and business partners [13].

Digitalization creates great opportunities for organizations and supply chain practices. Many organizations want to become more "digital" because they see the importance and value of digital technologies for their growth and business, and management support for such plans is also increasing [14]. The use of new technologies and digitalization is increasing rapidly, and this has affected all industries [13]. Supply chains and logistics services are no exception to this rule and are rapidly becoming digital [15].

Digital supply chain is the use of new technologies to manage an interconnected set of activities for coordination, planning and control of products and services between suppliers and consumers with the aim of creating more added value and creating integration and coordination between processes, and revenue growth [16]. A digital supply chain must pave the way for achieving these goals through tooling, connectivity, intelligence, automation, integration, and creative action [17]. Tooling means the application of systems with sensors, RFID, and other integrated components that provide the power to generate data to aid in decision making. Members of the digital

supply chain are smart systems that are fully interconnected and able to make decisions to optimize their global performance by collecting and analyzing large amounts of data. These systems use automated activities to replace less efficient resources and integrate all supply chain activities. Integrated supply chain activities include collaboration between all members, joint decision-making, information sharing, and the use of more efficient solutions to develop new values [17].

These features are achieved through the use of IoT technologies, add-on manufacturing, automation, industrial robots, augmented reality, blockchain, cloud computing, big data, physical cyber systems, and more [16].

In the digital supply chain, for instance, the Internet of Things combines business and web applications with machines, devices, products, materials, and people, transforming all factory processes, customers, and suppliers into one smart network [18]. Physical cyber systems, which include machines, storage systems, and production facilities, provide supply chain opportunities for real-time monitoring of production conditions and logistics activities by creating global integration throughout the supply chain, and provide the possibility of prognosis, diagnosis and remote control [19]. The cloud computing system also provides a platform that allows access to data and information at any time and place [20]. Also, big data provides the basis for descriptive analysis, forecasting, and prescribing appropriate solutions of stored data by providing applications [19].

2.2 Capabilities of Digital Supply Chain

The success of the digital supply chain requires the development of a set of capabilities. These capabilities should be able to act as a powerful tool to support operations-related strategies [21]. The capabilities of information and communication technology application, the participation of all stakeholders and the capabilities and abilities of human resources Sangwan, Bhakar [22] are the main capabilities that reduce the risk of failure in the digital supply chain [23]. Strategies and policies of the IT sector play an important role in the application of industrial revolution technologies [24]. Human resource strategies for benefiting from human capital, communication between suppliers and customers, ability to produce smart products and fast transportation are other effective capabilities in the digital supply chain [25].

2.3 Implementation of Digital Supply Chain

The digital supply chain's digitalization approach involves changes in social and technical structures through the use of commercial facilities and exchanges in the supply chain. Büyüközkan and Göçer [15] developed Digital supply chain development roadmap in terms of digitalization dimensions (with components of strategy,

organization and culture of operations, products and services and customer experience), technology implementation (components of technology enablers, system Project management, human-technology relations and technology infrastructure) and supply chain management (with process components, integration, reconfiguration, automation and data analytics tools). In a study, Garay-Rondero, Martinez-Flores [26] identified factors influencing supply chain implementation, and introduced intelligent logistics and distribution, warehousing automation, automated transportation, distribution robots, information integration and sharing, e-commerce, flexibility, digital reality, social media, store data retrieval technologies, customer behavioral data control, intelligent demand control based on ERP system, production automation, quality control robots, vertical and horizontal integration, and machine learning as the main feature of digital supply chain.

In general, literature review shows that the effective factors on the implementation of digital supply chain can be classified into three categories of underlying factors, empowering factors and accelerating factors.

Underlying factors are the factors that exist as the basis for the implementation of the digital supply chain in the organization. Standard and integrated data and processes are one of the factors that are key to the success of a digital supply chain [13, 27–32]. Taking innovative initiations in the digital supply chain requires the employment of skilled, capable and creative employees, who must continuously develop their skills in order to go on [7, 15, 33–35]. In addition to standard data and processes and skilled staff, employee participation is required in the successful conversion of a traditional supply chain to a digital supply chain, and without it, one cannot hope for a successful implementation of the digital supply chain [1, 13, 36, 37].

Speed, flexibility, global connectivity, real-time inventory, intelligence, transparency, scalability, innovation, cost-effectiveness and efficiency are key features of a digital supply chain [15].

It seems that a digital supply chain needs a key factor that can empower the chain in all sectors. Technology and its related subjects are among these empowering factors. Technology infrastructure [38–41], technology reliability [42–45], Security [7, 36, 46], and technology maturity [7, 43, 44, 47] are among the important factors related to technology which affects the performance and effectiveness of the application of technology.

Some factors also act as accelerators to speed up the implementation and success of the supply chain. Committed Leadership and Change Management [7, 13, 37, 48], Supportive Organizational Culture [13, 37, 43, 44, 48], and alignment of business and technology strategies [37, 43, 44, 48]. The presence of these three factors in a supply chain makes the acquisition of the features of a digital supply chain faster and in a way these factors have the role of accelerating the process of digitalization of the supply chain, but this should not be ignored that the absence of these factors in an organization would prevent success in establishing a digital supply chain.

Based on this and after examining the theoretical foundations related to the subject, we seek to identify the factors affecting the implementation of digital supply chain in the food industry and designing of its interpretive structural model.

3 Research Methodology

This research is a descriptive research in terms of analysis, which currently examines, describes and interprets the situation. The purpose of this study is to identify and analyze the factors affecting the implementation of digital supply chain in the food industry using interpretive structural modeling (ISM). In this study, first the effective factors were identified by reviewing the literature, and then through interviews with eight experts who had experience and knowledge and at least 5 years of experience in the food industry, the final factors were identified. Then, by designing a questionnaire, the experts' opinions were collected to construct an interpretive structural model and a digital supply chain implementation model was designed. The steps of the interpretive structural modeling method are as follows:

Step 1*: Formation of Structural Self-Interaction Matrix (SSIM)*

After identifying the final criteria in establishing a digital supply chain, the structural self-interaction matrix is formed. In this stage, the relationships between the effective factors in establishing the digital supply chain are analyzed using interpretive structural modeling and using four symbols. The symbols used in this section are:

V: *Factor i helps to realize factor j.*

A: *Factor j is realized by factor i.*

X: *Factors i and j both contribute to each other's realization.*

O: *Factors i and j are unrelated.*

In order to determine the relationships between factors, the factors are compared in pairs. And the respondent uses the above symbols to determine the relationships [49].

Step 2*: Formation of Reachability Matrix*

By substituting the symbols V, A, X, and O to zero and one for each variable, each structural self-interaction matrix is transformed into a binary matrix, called the initial reachability matrix [49].

Step 3*: Initial and final Reachability matrix*

According to the above mentioned rules, the initial reachability matrices are obtained. Final reachability matrices are obtained by including transferability. The transferability of conceptual relationships between variables is a basic assumption in interpretive structural modeling. Transferability means that if variable A affects variable B and variable B affects variable C, then A affects C. These transfer abilities are shown in the final reachability matrices [50].

Step 4*: Level Partitions and Model Drawing*

In this step, from the final reachability matrix, for each factor, reachability set and antecedent sets are derived. The reachability set consists of the factor itself and the other factor that it may impact, whereas the antecedent set consists of the factor

itself and the other factor that may impact it. After determining the reachability and antecedent sets, the intersection of these sets is derived for all the factors. In this way, a common set for each factor is obtained [51].

The factors for which the reachability and the intersection sets are the same occupy the top level in the ISM hierarchy. Once the top-level factors are identified in the first loop, they have to be removed from other factors and must be deleted. This process is continued until the level of each factor is found, and an interpretive structural model is drawn. MICMAC analysis is also performed at this level [50].

4 Findings

As mentioned, in this study, first, by reviewing the literature, the factors affecting the implementation of digital supply chain were identified. These factors were then provided to the interviewee team and after discussion, 15 criteria affecting the establishment of the digital supply chain were finalized. Table 1 shows the final criteria.

After the criteria are finalized, a self-interactive matrix is formed by comparing the pairs among the criteria. Table 2 shows the self-interaction matrix between the criteria.

Table 1 Factors affecting the implementation of digital supply chain

Criteria	Symbol	Source
Strategic alignment	S1	[37, 44, 48]
Innovative products	S2	[25]
Technological infrastructure	S3	[38–41]
organizational culture	S4	[13, 37, 43, 44, 48]
Technological trust	S5	[42–45]
Connections	S6	[22]
Technology maturity	S7	[7, 43, 44, 47]
Data standardization	S8	[1, 13, 36, 37]
Employee participation	S9	[1, 13, 36, 37]
Data security	S10	[7, 36, 46]
Technology compatibility	S11	[15]
Leadership of the organization	S12	[7, 13, 37, 48]
Staff training and development	S13	[7, 15, 33–35]
Technological awareness	S14	[52]
Project management system	S15	[15]

Table 2 Self-interaction matrix between criteria affecting digital supply chain implementation

	S15	S14	S13	S12	S11	S10	S9	S8	S7	S6	S5	S4	S3	S2	S1
S1	V	X	O	V	O	X	O	O	O	O	V	O	O	O	
S2	A	O	O	V	V	O	X	X	V	A	O	O	A		
S3	V	O	X	O	O	O	O	O	O	V	O	X			
S4	O	V	X	V	O	V	O	O	O	O	O				
S5	O	A	O	X	X	O	O	A	X	A					
S6	X	O	O	O	O	O	V	V	O						
S7	A	O	O	X	X	O	A	A							
S8	A	O	O	O	V	O	X								
S9	A	O	O	V	V	O									
S10	V	X	O	V	V										
S11	O	A	O	X											
S12	O	O	O												
S13	V	V													
S14	V														
S15															

Based on the above rules, the initial reachability matrices are obtained and then the final reachability matrices are obtained by including the transferability. The transferability of conceptual relationships between variables is a basic assumption in interpretive structural modeling. Transferability means that if variable A affects variable B and variable B affects variable C, then A affects C. These transferabilities are shown in the final reachability matrices and in the Table 3.

Then, by determining the reachability and antecedent sets for each factor, the level of each factor is determined. Factors whose antecedent and common set are quite similar are at the highest level of the interpretive structural model hierarchy. Thus, when the highest level of elements is identified in the first iteration, these elements must be separated from the other elements, or in other words, removed. This operation is repeated until the level of all elements is determined. To perform this operation, the level of all criteria is determined and the interpretive structural model is drawn according to the following Fig. 1.

As this table shows, the criteria of technology infrastructure, organizational leadership and organizational culture are considered as the basic criteria for implementing the digital supply chain. At the next level is employee participation, strategic alignment and staff training and development. At the third level, there are technological awareness and project management system. At the second level are data standardization, technological products and technology maturity, and at the first level are data security, technology trust, technology compatibility and technology communication.

In the next section, MICMAC analysis was performed. The purpose of this section is to analyze the influence and the degree of dependence of each factor. At this stage, the factors affecting the implementation of digital supply chain are classified into

Table 3 Final reachability matrix of factors affecting the implementation of digital supply chain

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
S1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1
S2	0	1	0	0	1	0	1	1	1	0	1	1	0	0	0
S3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S5	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0
S6	0	1	0	0	1	1	1	1	1	0	1	1	0	0	1
S7	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0
S8	0	1	0	0	1	0	1	1	1	0	1	1	0	0	0
S9	0	1	0	0	1	0	1	1	1	0	1	1	0	0	0
S10	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1
S11	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0
S12	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0
S13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S14	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1
S15	0	1	0	0	1	1	1	1	1	0	1	1	0	0	1

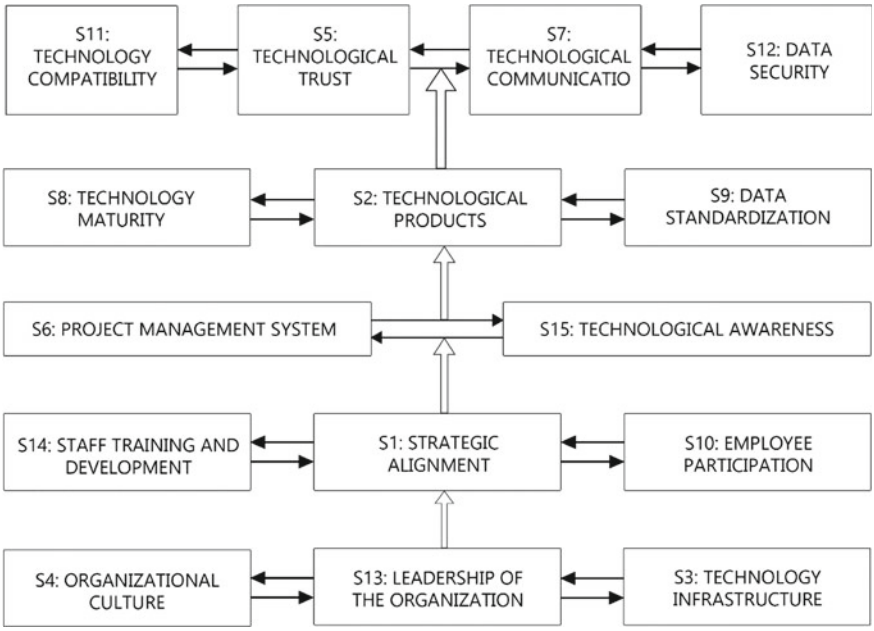

Fig. 1 Final interpretive structural model of criteria affecting the implementation of digital supply chain in the food industry

four groups. The first group includes autonomous factors (Cluster 1) that have weak influence and dependence. These factors are somewhat separate from other factors and have little correlation. The second group includes dependent factors (Cluster 2); which have weak influence but high dependence. The third group includes linkage factors (Cluster 3). These factors have high influence power and high dependence. In fact, any action on these factors causes a change on other factors. The fourth group includes independent (intrusive) and (Cluster 4) factors. These factors have high influence power and low dependence. Factors that have high influential power are called key factors. It is clear that these barriers fall into one of the two groups of independent or linkage barriers (Fig. 2).

As the figure above shows, the criteria for innovative products, technological trust, technology communication, technology maturity, data standardization, technology compatibility, and technology security fall into Cluster 2. These criteria have low penetration and effectiveness, but have high dependency and influence. Criteria for technology infrastructure, organizational culture, strategic alignment, employee participation, and staff training and development fall into Cluster 4. These criteria have low dependency but high influence. Also, the two criteria of project management system and technological awareness are in Cluster 3. These criteria have a high degree of influence and dependency that can be named as key variables.

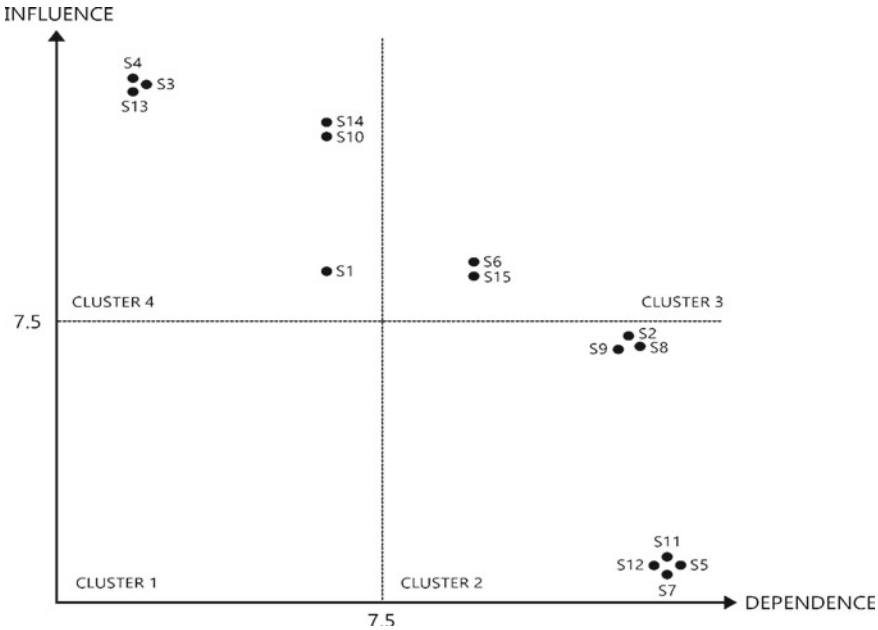

Fig. 2 MICMAC analysis of factors affecting digital supply chain implementation

5 Conclusion

As mentioned, due to the extensive environmental changes, organizations are forced to move towards the establishment of a digital supply chain. Since the food industry is also one of the important industries in which speed of response is one of its most significant features, this study attempted to propose a model for establishing a digital supply chain in this industry. Based on the results obtained from the interpretive structural modeling's output, the variables of technological infrastructure, organizational leadership and organizational culture are the basic variables for the establishment of digital supply chain in the food industry. Since the basis for the implementation of digital supply chain is the use of new technologies, especially the technologies introduced in the Industrial Revolution 4, so it is necessary to provide the necessary infrastructure for its application. These include the provision of telecommunications equipment, fiber optic networks, mobile networks, financial resources to invest in this sector, cloud space for data storage, and so on.

Organizational culture is also one of the key variables that acts as a part of economic function and includes customer attitudes, beliefs and expectations that can affect employees' behavior. Since moving from a traditional supply chain to a digital supply chain requires organizational support and employee support, undoubtedly, this will not be possible without a culture that encourages the development and cooperation of employees, and the project will be questioned.

In addition to organizational culture, the role of leaders has a great impact on starting the transition from traditional supply chain systems to the digital approach. Transformational and exchange leadership style can affect the understanding of the usefulness and ease of use and deployment of the digital system. Exchange leadership style can affect cost effectiveness and express the benefits of cost reduction considerations. But transformational leadership style challenges people more through creativity and exploration, and increases the likelihood that people will embrace technology more easily [53]. The ideal performance of leaders in their role makes them a good role model in the eyes of employees and this helps leaders to improve the organization's vision. These types of leaders encourage employees to engage in risky activities such as moving to a digital supply chain system and to operate more effectively in an environment of uncertainty [54].

After this level, there are three variables of strategic alignment, employee participation and staff training and development. Strategic alignment refers to the alignment between business strategies and sectoral strategies, including IT strategies. IT and business plans should be in line with organization's core strategies, taking into account environmental and organizational constraints. Strategic alignment leads to productivity, rapid and appropriate access to information and facilities, and the provision of new services to the business sectors. The digitalization of the supply chain requires fundamental changes in structures, processes, employee capabilities, and so on. This will not happen without the participation and support of employees. Continuous changes in today's competitive world also require employee empowerment

and the acquisition of new and up-to-date skills and employee retention. Therefore, organizations should pay serious attention to staff training and empowerment.

At the third level, there are technology awareness and project management system. Staff training should lead to staff awareness of capabilities, applications and the way technology is used. The systems and technologies used in the supply chain are very complex due to the varied and unpredictable interrelationships between its subsystems. Therefore, it is necessary for staff training to increase their awareness of technology so that they can benefit from it better. In order to digitize the food industry, supply chain, it is necessary to implement several projects in various fields. To manage them, the establishment of a project management system can be very helpful.

At the third level, there are innovative products, data standardization and technology maturity. The emergence of new technologies has made value creation in the supply chain one of the priorities of companies operating in various industries, and these technologies provide tremendous opportunities for the transition to a new era and the production of innovative products. On the other hand, logistics and supply chain traditionally create a lot of unused data. Companies used to store their data in any form and wherever they wanted, leading to a fragmented ecosystem that made it practically difficult to integrate operations across the supply chain. Therefore, to standardize the food industry supply chain and increase interoperability between components, data standardization is a very high priority. Another variable at this level is the maturity of technology, which indicates the ability to fully accept digitalization in all aspects of the organization.

At the first level, there are technology trust, technology communications, technology compatibility and technology security. Technology security indicates the development of security systems to address potential risks. Technology trust indicates the proper functioning of the system, and technology communication indicates the concept of compatibility and communication of technology components with each other.

The results of MICMAC analysis showed that the two variables of technological awareness and project management system are the two key variables in the implementation of digital supply chain management. Therefore, food industry companies are advised to focus on these two variables to digitize the supply chain.

References

1. Hofmann, E. et al.: Supply chain management and Industry 4.0: conducting research in the digital age. Int. J. Phys. Distrib. Logistics Manage. (2019)
2. Hagberg, J., Sundstrom, M., Egels-Zandén, N.: The digitalization of retailing: an exploratory framework. Int. J. Retail Distrib. Manage. (2016)
3. Min, S., Zacharia, Z.G., Smith, C.D.: Defining supply chain management: in the past, present, and future. J. Bus. Logist. **40**(1), 44–55 (2019)
4. Penthin, S., Dillman, R.: Digital SCM (2015)

5. Farahani, P., Meier, C., Wilke, J.: Digital supply chain management agenda for the automotive supplier industry. In: Shaping the Digital Enterprise, pp. 157–172. Springer (2017)
6. Ageron, B., Bentahar, O., Gunasekaran, A.: Digital supply chain: challenges and future directions. In: Supply Chain Forum: An International Journal. Taylor & Francis (2020)
7. Subramaniyam, M. et al.: Digital supply chain in the food industry: critical success factors and barriers. In: 2021 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). IEEE (2021)
8. Sahara, C. R. et al.: Exploring the key factor categories for the digital supply chain. In: 9th International Conference on Operations and Supply Chain Management, Vietnam 2019
9. Banerjee, A., Lücker, F., Ries, J. M.: An empirical analysis of suppliers trade-off behaviour in adopting digital supply chain financing solutions. Int. J. Oper. Prod. Manage. (2021)
10. Kumar, A., Singh, R.K., Modgil, S.: Exploring the relationship between ICT, SCM practices and organizational performance in agri-food supply chain. Benchmarking: An Int. J. (2020)
11. Dwivedi, Y.K., et al.: Artificial Intelligence (AI): multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. Int. J. Inf. Manage. **57**, 101994 (2021)
12. Gürdür, D., El-khoury, J., Törngren, M.: Digitalizing Swedish industry: What is next?: Data analytics readiness assessment of Swedish industry, according to survey results. Comput. Indus. **105**, 153–163 (2019)
13. Cichosz, M., Wallenburg, C.M., Knemeyer, A.M.: Digital transformation at logistics service providers: barriers, success factors and leading practices. Int. J. Logistics Manage. (2020)
14. Bughin, J., Chui, M., Manyika, J.: An executive's guide to the Internet of Things. McKinsey Q. **4**, 92–101 (2015)
15. Büyüközkan, G., Göçer, F.: Digital supply chain: literature review and a proposed framework for future research. Comput. Ind. **97**, 157–177 (2018)
16. Rasool, F., Greco, M., Grimaldi, M.: Digital supply chain performance metrics: a literature review. Measur. Business Excellence (2021)
17. Wu, L. et al.: Smart supply chain management: a review and implications for future research. Int. J. Logistics Manage. (2016)
18. Marwedel, P.: Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things. Springer Nature (2021)
19. Radanliev, P., et al.: Artificial intelligence in cyber physical systems. AI & Soc. **36**(3), 783–796 (2021)
20. Sadeeq, M.M., et al.: IoT and Cloud computing issues, challenges and opportunities: a review. Qubahan Acad. J. **1**(2), 1–7 (2021)
21. Queiroz, M. M. et al.: Industry 4.0 and digital supply chain capabilities: a framework for understanding digitalisation challenges and opportunities. Benchmarking: Int. J. (2019)
22. Sangwan, K. S., Bhakar, V., Digalwar, A.K.: A sustainability assessment framework for cement industry–a case study. Benchmarking: Int. J. (2019)
23. Ivanov, D., Tsipoulanidis, A., Schönberger, J.: Digital supply chain, smart operations and industry 4.0. In: Global Supply Chain and Operations Management. Springer, pp 481–526 (2019)
24. Bibri, S.E.: The IoT for smart sustainable cities of the future: an analytical framework for sensor-based big data applications for environmental sustainability. Sustain. Cities Soc. **38**, 230–253 (2018)
25. Scuotto, V., et al.: A multiple buyer–supplier relationship in the context of SMEs' digital supply chain management. Prod. Planning Control **28**(16), 1378–1388 (2017)
26. Garay-Rondero, C.L. et al.: Digital supply chain model in Industry 4.0. J. Manuf. Technol. Manage. (2020)
27. Aćimović, S., Stajić, N.: Digital supply chain: leading technologies and their impact on Industry 4.0. Bus. Logistics Modern Manage. (2019)
28. Daxböck, C., Kröber, J., Bergmann, M.: Digitized performance management along the supply chain. In: Performance Management in Retail and the Consumer Goods Industry, pp. 405–423. Springer (2019)

29. Korpela, K., Hallikas, J., Dahlberg, T.: Digital supply chain transformation toward blockchain integration. In: Proceedings of the 50th Hawaii International Conference on System Sciences (2017)
30. Nekrasov, A., Sinitsyna, A.: Integrated architectural approach to ensuring stability of processes of the digital supply chain. In: International Conference on Reliability and Statistics in Transportation and Communication. Springer (2020)
31. Perboli, G., Musso, S., Rosano, M.: Blockchain in logistics and supply chain: a lean approach for designing real-world use cases. IEEE Access **6**, 62018–62028 (2018)
32. Simchenko, N., Tsohla, S., Chyvatkin, P.: IoT & digital twins concept integration effects on supply chain strategy: challenges and effect. Int. J. Supply Chain Manage. **8**(6), 803–808 (2019)
33. Mitra, T., Kapoor, R., Gupta, N.: Studying key antecedents of disruptive technology adoption in the digital supply chain: an Indian perspective. Int. J. Emerg. Markets (2022)
34. Wahab, S. N., Rajendran, S. D., Yeap, S. P.: Upskilling and reskilling requirement in logistics and supply chain industry for the fourth industrial revolution. LogForum **17**(3) (2021)
35. Wang, B., Ha-Brookshire, J. E.: Exploration of digital competency requirements within the fashion supply chain with an anticipation of industry 4.0. Int. J. Fashion Des. Technol. Educ. **11**(3), 333–342
36. Attaran, M.: Digital technology enablers and their implications for supply chain management. In: Supply chain forum: an international journal. Taylor & Francis (2020)
37. Osmundsen, K., Iden, J., Bygstad, B.: Digital transformation: drivers, success factors, and implications. In: MCIS (2018)
38. Afanasyev, V.Y., et al.: Digitalization of energy manufacture: infrastructure, supply chain strategy and communication. Int. J. Supply Chain Manage. **8**(4), 601–609 (2019)
39. Akyuz, G.A., Rehan, M.: Requirements for forming an 'e-supply chain.' Int. J. Prod. Res. **47**(12), 3265–3287 (2009)
40. Premkumar, G.P.: Interorganization systems and supply chain management. Inf. Syst. Manag. **17**(3), 1–14 (2000)
41. Xue, L., et al.: Risk mitigation in supply chain digitization: system modularity and information technology governance. J. Manag. Inf. Syst. **30**(1), 325–352 (2013)
42. Min, H.: Blockchain technology for enhancing supply chain resilience. Bus. Horiz. **62**(1), 35–45 (2019)
43. Vogelsang, K., et al.: Success factors for fostering a digital transformation in manufacturing companies. J. Enterprise Transf. **8**(1–2), 121–142 (2018)
44. Vogelsang, K., et al.: Barriers to digital transformation in manufacturing: development of a research agenda (2019)
45. Zhang, H., Nakamura, T., Sakurai, K.: Security and trust issues on digital supply chain. In: 2019 IEEE International Conference on Dependable, Autonomic and Secure Computing, International Conference on Pervasive Intelligence and Computing, International Conference on Cloud and Big Data Computing, International Conference on Cyber Science and Technology Congress (DASC/PiCom/CBDCom/CyberSciTech). IEEE (2019)
46. Liu, Z., Li, Z.: A blockchain-based framework of cross-border e-commerce supply chain. Int. J. Inf. Manage. **52**, 102059 (2020)
47. Khajavi, S.H., Holmström, J., Partanen, J.: Additive manufacturing in the spare parts supply chain: hub configuration and technology maturity. Rapid Prototyping J. (2018)
48. Kane, G.C., et al.: Coming of age digitally. MIT Sloan Manage. Rev. Deloitte Insights **59**(5), 1–10 (2018)
49. Kinker, P., et al.: Identifying and evaluating service quality barriers for polytechnic education: an ISM-MICMAC approach. Mater. Today: Proc. **46**, 9752–9757 (2021)
50. Swarnakar V., Tiwari, A.K., Singh, A.: Evaluating critical failure factors for implementing sustainable lean six sigma framework in manufacturing organization: a case experience. Int. J. Lean Six Sigma (2020)
51. Sushil, S.: Interpreting the interpretive structural model. Glob. J. Flex. Syst. Manag. **13**(2), 87–106 (2012)

52. Chawla, S.: Design and implementation of IoT based low cost, effective learning mechanism for empowering STEM education in India. Turk. J. Comput. Math. Educ. (TURCOMAT) **12**(13), 125–133 (2021)
53. Schepers J., Wetzels, M., de Ruyter, K.: Leadership styles in technology acceptance: do followers practice what leaders preach? Manag. Serv. Qual. Int. J. (2005)
54. Nemanich, L.A., Keller, R.T.: Transformational leadership in an acquisition: a field study of employees. Leadersh. Q. **18**(1), 49–68 (2007)

Analysis of the Introduction of Electronic Services in Public Administration: World Experience

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Abstract To deepen the digitalization of society, research on the development and comparative analysis of the introduction of electronic services in public administration is relevant. Such electronic services mainly include electronic funds transfer, e-government, e-information, electronic data interchange, e-banking, e-cash, e-consulting, e-trade, e-marketing, e-insurance, e-justice, etc. This paper examines the world's digital economy. This world's digital economy consists of financial and trade transactions. These transactions are implemented by means of computer networks. The introduction of government citizens' services with the usage of information and communication technologies has been studied.

Keywords e-government · Information and communication technologies · Electronic services · Digitalization · Internet

1 Introduction

E-commerce or electronic commerce is the sphere of the digital economy, which contains financial and trade transactions. The financial and trade transactions are conducted with help of computer networks and business procedures connected to

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these transactions. E-commerce includes electronic funds transfer, e-government, e-information, electronic data interchange, e-justice, e-banking, e-cash, e-consulting, e-trade, e-marketing, e-insurance, etc.

The first e-commerce systems [1, 2] were performed in 1960 in the United States in their simplest form. Transportation businesses use them mostly to order tickets and exchange data between transportation services [3] before preparing for flights. American Airlines has implemented a system to automate the procedure for booking seats for flights. The IBM-developed development was called SABER (Semi-Automatic Business Research Environment, Saber) and became fully operational in 1964. Primarily, e-commerce depends on non-Internet interaction and considered by the usage of numerous separate standards and protocols. The first generally accepted standard was Electronic Data Interchange, adopted in 1980. This standard is defined as characteristic commercial transactions and documents to be processed and transmitted over digital networks [4, 5].

The development of the Internet achieved to an important decrease in e-commerce [6] due to the low charge of data exchange. It as well stimulated the e-commerce additional development that currently distinguishes the following levels of its determination: Business-to-Business (B2B), Business-to-Customer (B2C), and etc. B2B e-commerce is e-commerce between businesses. This category of e-commerce deals with the relationship between commercial activities.

Business-to-Customer e-commerce is electronic commerce between businesses and persons, including gathering data from clients, purchasing physical items or data/electronic goods, and, for info goods, receipt of goods (programs, e-books) via an electronic network. Business-to-Customer e-commerce is the second-largest and first form of e-commerce. Examples of B2C models are online retail businesses.

Consumer-to-consumer e-commerce (C2C) is a trade between persons or customers. This kind of e-commerce is categorized by e-markets growth and online auctions [7–9], particularly in vertical businesses. C2C may have the highest potential for developing innovative markets. All areas of internal and external interactions in e-government can be divided into 5 main types (Fig. 1).

In several cases, e-commerce can decrease the resale of a product from creator to the buyer. The main benefit of e-commerce is a substantial decrease in the transaction cost. Extra numbers of companies worldwide are realizing e-commerce solutions in their business. The use of e-engagement tools does not automatically ensure e-democracy. Even if we consider this toolkit to shape the relations of citizens with each other, between government, business, still society must overcome the difficulties of another plan—organizational, ideological, political, and so on [10–13]. The defining fundamentals of citizen contribution in government [14–16] using data and communication technologies (ICT) [17–21] are:

- posting data on government activities on government websites (data);
- interactive discussion of the problems of social development on the websites of the authorities/e-consultations;
- government reply to citizens' e-petitions/e-decision making [22].

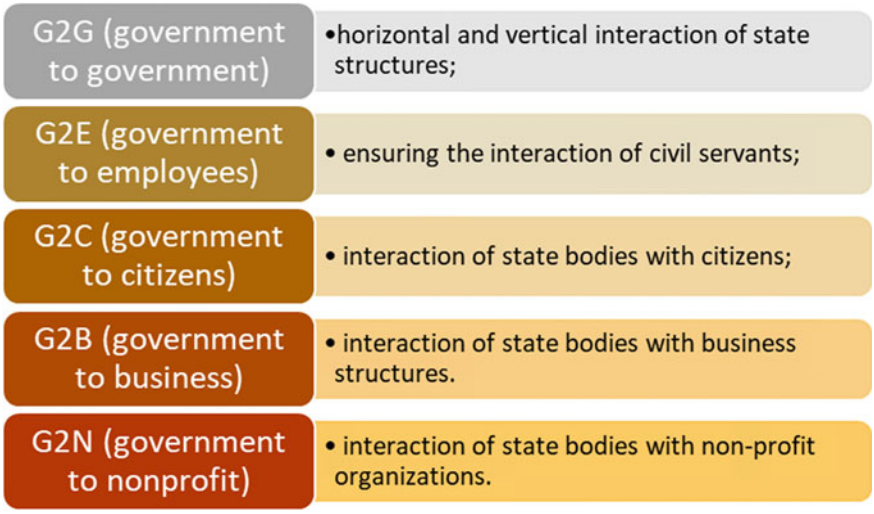

Fig. 1 Five basic types of internal and external interactions in e-government

2 Electronic Democracy in Ukraine

E-government includes e-democracy and the delivery of e-public services. Publication of information by electronic means as an activity refers to e-services. When we talk about e-democracy [23, 24] in the narrow sense, we mean the use of ICT to ensure (electronic support) the rights of citizens. In this case, only the technical side of submitting applications, appeals, inquiries to the authorities on behalf of citizens changes. Using his legal right to receive a particular certificate, a citizen can apply to the court in writing or, for example, using e-mail. In a broad sense, E-democracy involves the community's involvement with the help of modern information technology to solve various socio-political problems. It is in this context that we will consider e-democracy [25, 26]. An example is the interactive participation of residents in a local council meeting. During the broadcast of the meeting on the Internet, everyone interested can express their attitude to the council's decisions, the speeches of deputies, and thus—to influence the position of the authority. Rendering to the International Renaissance Foundation, the main problems delay the e-democracy and e-government development in Ukraine (see Fig. 2).

Based on this list, we can conclude that much of the problem is caused by the attitude or inability of the state (for various reasons) to influence the situation. After all, both administrative reform and the limitations in the provision of administrative services through ICT [27] and other factors (including problems in the field of training of civil servants in Internet technologies) are all the competencies of public authorities and local governments.

The use of e-engagement tools does not automatically ensure e-democracy. Even if we consider this toolkit to shape the relations of citizens with each other, between

Problems that delay the e-democracy and e-government development in Ukraine	introduction of e-government technologies requires modernization, first of all, of the public administration system, carrying out of effective administrative reform;
	imperfect procedures for providing and receiving administrative services through the use of information and communication technologies (ICT);
	lack of standard approaches and standard requirements in the implementation of e-government technologies;
	slow formation of e-democracy (the opportunity for everyone through ICT to participate in the formation and implementation of state and local policies);
	insufficiently effective interaction of executive bodies, local self-government bodies and non-governmental public organizations, necessary for the development and implementation of specific plans for the implementation of e-government technologies;
	low level of awareness, motivation and training of civil servants, representatives of non-governmental organizations, businesses and the population in e-government technologies.

Fig. 2 The main problems that delay the e-democracy and e-government development in Ukraine

government, business, still society must overcome the difficulties of another plan—organizational, ideological, political, and so on [28]. The defining elements of citizen participation in government using ICT are presented in Fig. 3.

According to domestic experts, the development of e-democracy in Ukraine has gone through three main stages (Table 1).

The defining elements of citizen participation in government using ICT	posting information about government activities on government websites (e-information);
	interactive discussion of the problems of social development on the websites of the authorities (e-consultations);
	government response to e-petitions of citizens (e-decision making).

Fig. 3 The defining elements of citizen participation in government using ICT

Table 1 Stages of development of e-democracy in Ukraine

Stage number	Period	Description
1st stage	2000-2001	was of a preparatory nature, the most general aspects of the use of modern ICT were determined, and the necessary basis for further actions of the state in this direction was formed.
2nd stage	2002-2003	directly related to the formation of e-government mechanisms in Ukraine, which aimed to increase the efficiency and transparency of public authorities and local governments, improve public awareness of the activities of these bodies and enhance feedback between government and society through the Internet. Counting of this stag e can be conditionally conducted from the Resolution of the Cabinet of Ministers of Ukraine On the procedure for publishing information on the Internet on th e activities of the legislature (January 4, 2002 , 3-2002-n), which approved the Procedure for Publishing Information on the Internet Executive Authorities. During this period, the Decr ee of the President of Ukraine On Additional Measures to Ensure Openness in the Activities of Public Authorities and the Resolution of the Cabinet of Ministers of Ukraine On Measures to Further Ensure Openness in the Activities of Executive Bodies were adopted, the necessity of creating their websites by state authorities and local self-government bodies, prompt placement of official information on their activities, clear r equirements for the content of government websites; creation of a government portal to form and implement a stable and understandable to citizens' economic and social policy of the state. To this end, the entities responsible for the implementation of these regulations have been identified. The tasks of state and local self -government bodies were also defined regarding the functioning of official websites, their content, prompt publication of information, provision of relevant statistical information, preve ntion of restrictions on the right to public information, regular press conferences, including the Internet.
3rd stage	Started in 2003	with the adoption of the Resolution of the Cabinet of Ministers of Ukraine On Measures to Create an Electronic Information System. Electronic Government (February 20, 2003 , № 208) and continues to this day. The objectives of the proposed measures for the development of the information society were to provide

(continued)

Table 1 (continued)

Stage number	Period	Description
3rd stage	Started in 2003	information and other services to citizens and legal entit ies through the use of electronic information system Electronic Government, which provides information interaction between executive bodies and citizens, provides information and other services based on modern information technologies. During 2004 -2009, th e order of interaction between state authorities and citizens was supplemented by several resolutions of the Cabinet of Ministers aimed at streamlining the interaction between the executive branch and civil society institutions. Aimed at developing and imp lementing an effective mechanism of communication between executive bodies and civil society institutions and Concept of Assistance to Executive Bodies in Civil Society Development, approved by the Cabinet of Ministers on November 21, 2007. civil society, strengthening democracy. In 2009, the Concept was amended, which concerned primarily the mandatory coverage of the results of their activities in the media and their public discussion.

2.1 Development of e-Democracy and e-Government in Ukraine

The Resolution of the Central Committee of the Soviet Communist Party (1960) and the Council of Ministers of the USSR was adopted, which provided for the deployment of work on creating the National Automated System of Planning and Management of the National Economic (NAS). V. Glushkov suggested regulating the national economy grounded on the cybernetics achievements with extensive usage of mathematical models. These mathematical models define completely the procedures which occurred in the economy. The necessary element of NAS provided a system of non-cash payments for individuals. Technologically, NAS was a set of a three-stage system of large computer centers united by a particular broadband communication network, which provides all the data required for the government. However, for some reason, the project in total, which would give the result conceived by V. Glushkov, was not implemented. Still, many developments related to it were embodied in automated control systems of the lower level.

The outstanding modern scientist V. Glushkov, who made a significant contribution to the establishment of cybernetics and computer technology in Ukraine and the former Soviet Union, and in the world as a whole, formulated an idea that was in principle worked out to the project stage, which later received name e-government.

In 1998, the Verkhovna Rada of Ukraine adopted two laws on the National Informatization Program and On the Concept of the National Informatization

Program, which deepened and disseminated V. Glushkov's idea of the widespread overview of computer information technologies and cybernetic methods in all spheres of life. The laws define the term informatization—"a set of interrelated organizational, legal, political, socio-economic, scientific and technical production processes aimed at creating conditions to meet the information needs of people and society through the creation, development and use of information systems, networks, resources and information technology, which are based on the use of modern computer technology" [29]. It was noted that informatization affects the interests of national interests, improves economic governance, development of scientific businesses, advances social and economic relations, modern technologies, increases efficiency, and improves the spiritual life and further the democracy development.

The concept stated that the state policy of informatization should be aimed at comprehensive democratization of the creation and consumption processes of information, universal access to information resources and services, protection of individual rights from information intrusion, etc. The state had a task to cover all areas of activity in the country with informatization processes and, first of all, to form a national informatization infrastructure. Also need to digitize strategic directions of statehood development, security and defense, socio-economic development processes, priority 20 sectors of the economy, finance and monetary system, science, education, social scope, ecology and usage of natural resources, and culture.

In 2007, the law on the Basic Principles of Information Society Development in Ukraine until 2015 was adopted in Ukraine. Even though this law does not use the concept of e-government, the essence of the introduction of e-government technologies is depicted in it. Thus, one of the main strategic goals of information society development in Ukraine is the usage of ICT to advance government administration, relations between the state and people, the electronic forms formation of interaction between public authorities and, local governments and persons and legal bodies. One of the tasks determining the status and list of mandatory electronic services to be provided by public authorities and local governments to legal individuals and persons, guaranteeing the implementation of the single window principle.

The term e-democracy is considered in two senses. When we talk about e-democracy in the narrow sense, we mean using ICT to ensure (electronic support) human rights. In this sense, only the technical side of submitting applications, appeals, inquiries to the authorities on behalf of citizens is changing. A person can apply to the court in writing or via e-mail, using his legal right to obtain any information.

In the broadest sense, E-democracy is to involve citizens in the use of modern information technology to solve various socio-political problems.

In this sense, e-democracy is considered. An example is the interactive participation of people in a local council meeting. During the broadcast of the discussion on the Internet, everyone can talk about their attitude to the decisions of the council, the speeches of deputies, and in general—to influence the decisions of the authority (see Fig. 4).

Here are some problems that, according to the International Foundation 'Renaissance', hinder the development of e-government and e-democracy in Ukraine (Fig. 5). Taking into consideration these problems, we can conclude that most of the problems

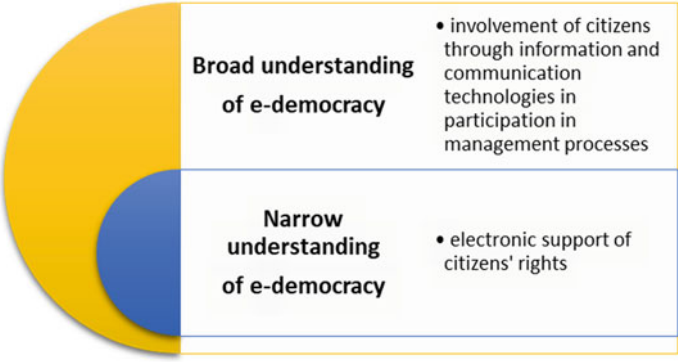

Fig. 4 The concept of e-democracy

are created by the attitude or inability of the country (for various reasons) to change the situation in the state. Because of administrative reform and the limitations in the provision of administrative services through ICT and other factors (including problems in the training of civil servants of Internet technologies), this is primarily a task of public authorities and local governments.

Problems of development of e-governing in Ukraine:

- The introduction of e-government technologies requires modernization, especially of the public administration system, and effective administrative reform.
- Imperfect procedures for providing and receiving administrative services through the use of information and communication technologies (ICT).
- Lack of standard approaches and standard requirements in the implementation of e-government technologies.
- Slow formation of e-democracy (opportunity for everyone through ICT to participate in the formation and implementation of state and local policies.
- Insufficiently effective interaction of executive bodies, local self-government bodies and non-governmental public organizations, necessary for the development and organization of specific plans for the implementation of e-government technologies.
- Low level of awareness, motivation and training of civil servants, representatives of non-governmental organizations, business and non-population of e-government technologies.

Fig. 5 Problems of e-government development in Ukraine

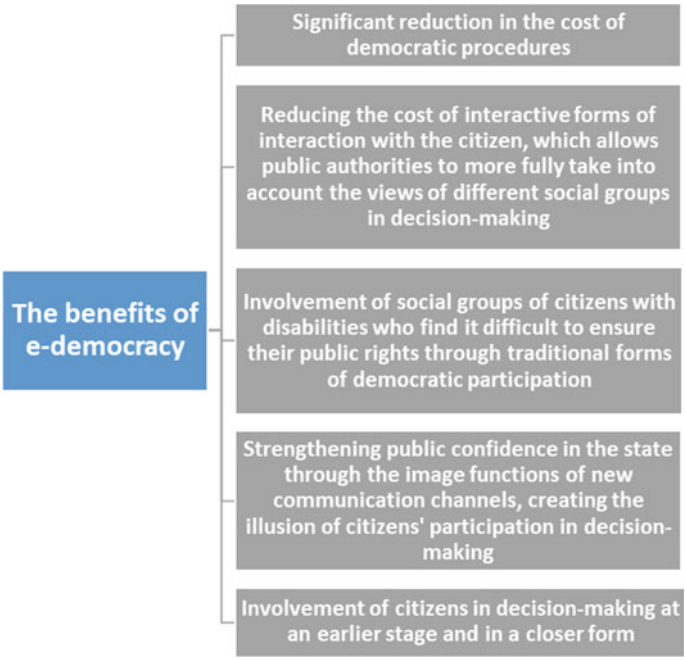

Fig. 6 The benefits of e-democracy

Technology only helps, not solves the problem. Therefore, it is necessary to combine with the main non-electronic tools for access to information, consultation, and public participation to get the most out of ICT use.

Among the advantages of e-democracy are the following (Fig. 6).

Thus, we can conclude that e-democracy, on the one hand, helps to develop democratic institutions. On the other hand—it is difficult, especially technical. For example, the Internet provides opportunities for a new organization of elections, primarily the ability to vote from personal computers. However, practice shows that there is no permission to use new technical knowledge due to technical problems.

Analysis of the situation in Ukraine shows that the spread of technologies that facilitate the involvement of citizens in politics has not yet shown high results of e-democracy in the Ukrainian state.

2.2 Analysis of e-commerce Market Development in Ukraine

The e-commerce market is developing very fast, despite the global crisis and various negative situations in Ukraine. According to eMarketer, the average growth rate in the world is about 18–20% per year, which is about 10–12% of all retail sales. Moreover, it is one of the most successful growing industries in our country.

According to analytical studies, e-commerce in Ukraine is growing and developing dynamically. Thus, in 2017, the penetration rate of Internet users amounted to 64.54% of the total population, which is about twenty-three million people.

This is usually a positive trend, but this figure reaches 90% in developed countries. The constant growth of Internet users contributes to the growing popularity of e-commerce and is profitable in terms of money, labour and other costs.

According to EVO, the volume of online trade-in 2017 grew to UAH 50 billion, which is about 30–40% more than in 2016. Today, our country's online trade is about 3% of all retail and it's not much, because in neighboring countries this figure is about 10–18 15%, which makes it clear that we have room to grow. Especially, if we consider the figures not in percentages, but absolute terms.

Every year, people start to trust online stores more and spend a lot of money buying online. And although a Ukrainian can spend about $714 a year, while a German spends $677, this does not reflect the real picture. The problem is that these purchases are still made by 10% of the total population and usually residents of large cities. The reason is that most people do not trust online shopping. The main deterrent is the inability to see the product, so you cannot be sure of its quality. UMG conducted a study and identified the main reasons for refusing to buy online.

Distrust of payment systems due to the security of confidential data is quite common among Ukrainians. Not understanding the fact that cards can be used to securely pay for online purchases is a kind of catalyst for the industry. As a rule, more than half of people over the age of 50 do not use payment cards for payment, let alone mobile banking. They believe that cash payment is more reliable for them. As a result, only 4% of the total population pays in cash. For comparison in the UK and the US, this figure reaches 75%.

Before the devaluation of the hryvnia and the crisis, the annual turnover of Rozetka (the market leader in e-commerce) was about $350–400 million, while Amazon was earning $106 billion using advanced technology and drones to deliver goods.

The development of e-commerce is hampered by several factors, including the imperfect legal framework, as well as differences between laws and international standards, distrust of digital signatures, low awareness of citizens about the security of e-commerce and e-payments, unprepared business and usually lagging in technology development.

Moreover, even government agencies have begun to trust e-commerce. This is how the Prozorro public procurement system was created. This system greatly simplifies the tender process and, most importantly, makes it more transparent. Thanks to this system, corruption, which is very widespread in this area, has been partially prevented.

The most common purchases from Ukrainians are electronics 23%, clothing, footwear and accessories 25% and cosmetics and perfumes 19%. The activity of buying on social networks is also growing. This figure is growing for various reasons. Some people buy goods because of the lower price, some because they do not need to go anywhere, but it is possible to order with home delivery, ie saving time, and for some it is convenient. You can just take a picture of the thing, and then, thanks

to a smart search, find it on the Internet and order. Photo search is already available on Instagram, Pinterest and Amazon.

Analysis of prospects and trends that may contribute to the development of e-commerce, the following:

- stabilization of the political situation in the east and development of the country's economy;
- increasing Internet penetration;
- expansion of the 3G network and introduction of 4G, which will lead to the growth of mobile commerce;
- growing confidence in e-commerce and the payment system;
- popularization of marketplaces;
- individual approach to the client taking into account all desires, which will increase the client's loyalty to e-commerce.

3 World e-Commerce Market

Four out of seven billion people are connected to the Internet. Global penetration is 52%, most of the traffic is on smartphones. The growing penetration of digital technologies has triggered a growth in investment on the Internet by 17%. By the end of 2019, total online store sales worldwide are predictable to reach two trillion dollars. Growth will be increase to the 6%.

According to the results of 2017, exactly 47% in the field of e-commerce will fall in China. In financial terms, this is approximately 900 billion dollars. Thus, this country will rank first in the world in e-commerce sales, moving from this place to the United States. North America is the second-largest regional market in e-commerce. The sales in the United States and other countries are projected at 423 billion dollars, an increase of +15, 6%. By 2020, the total sales of e-commerce in the world will increase in twice.

In Europe, the e-commerce share in GDP is reasonably high, the uppermost frequency was registered in Great Britain at 7, 9%, followed by China at 5, 8% and France at 3, 59%. Additionally, has the highest share of consumers who buy goods and services by mean of online. Furthermore, 81% of UK population has good access to the Internet, 98% is shop online. 81, 5% of all online trades from Europe account for Germany, United Kingdom, and France. This indicator is stable growth every year.

Great Britain is the e-commerce center in Europe. The volume of online sales in B2C is three times higher than in the second-largest market on the continent—Germany. Amazon is the top platform in a word—accounts for 54% of all sales.

According to foreign sources, the main difficulties in the e-commerce sphere are the lack of security of data transmitted over the Internet. Additional essential issues are the communications quality.

3.1 E-Democracy in Canada

Canada has become one of the first countries in the world to innovate in the field of e-government, in particular in solving the problem of open access to information of government agencies. In 1994, the government proposed a project to provide services to government agencies through IT, which was called e-government.

The project consisted of three stages of implementation, and within five years, Canada had to form an e-government system. As a result of applying the modular principle, the system was divided into four stages:

- Canada's site providing access to context;
- information portal consisting of sub portals;
- middleware (software), consisting of a search engine, business process automation system, application and data integration systems;
- infrastructure software, consisting of a system for managing paper and e-documents, e-storage and database management system (DBMS).

Today, the Canadian government works and interacts directly with the people through the most powerful information portal, which brings together up to 500 Internet sites. Canada is one of the world leaders in creating e-government for the use of ICT and the Internet in government interactions with citizens, businesses, and domestic interactions.

Canada's success is largely due to a comprehensive approach to modernizing the entire system of government, which includes the following areas:

- a clear division of powers between the federal, provincial and municipal levels of government;
- availability of a strategy for the use of ICT in all spheres of state activity;
- coordination in the management of e-government infrastructure (including clear control over the spending of budget funds);
- partnership of government agencies with society and business in the implementation of e-government projects;
- adjustment of legislation.

Before considering the peculiarities of building a federal portal Governance Online, we can note the high demand for an electronic version of the government in the daily lives of Canadians, for whom the problem of Internet access is almost completely solved. For example, in the last 12 months, 74% of all Canadian Internet users have visited the Government portal at least once. Without eliminating other channels of interaction, the Internet should be recognized as the most promising channel for communication with citizens in Canada for the next 5 years. The Governance OnLine project solves the following tasks for the government, which are shown in Fig. 7.

Despite the benefits (Fig. 7) of using the Internet portal, new approaches required project management. Ensuring maximum efficiency of limited financial resources at the high cost of e-government projects, solving problems of leadership and motivation

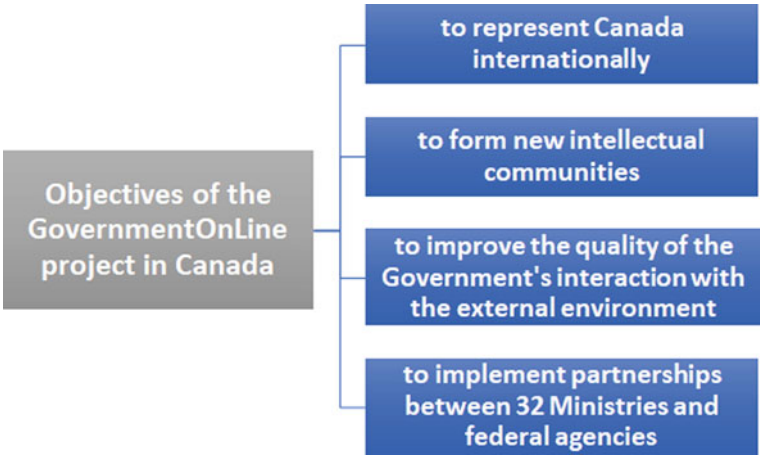

Fig. 7 Objectives of the GovernmentOnLine project

at all levels of government, the transition from hierarchical management to horizontal model, overcoming the objective complexity of ICT projects, project implementation across the country. The Government of Canada is convinced that the increase in the quality of public services is primarily due to the constant receipt of feedback from Canadians.

An important factor in the success of the Government of Canada and, in particular, e-government, is gaining public confidence in the work of statesmen. The main need.

Canadian citizens need for civil servants is transparency in their work. Canadians expect their government to provide clear, high-quality, convenient services that will ensure a fair outcome. After all, there is a contradiction between the simplicity of the service and improving its quality: the use of transactional services is not always easy to use. The main fears of the society about e-government were:

- raising the tax to provide better services;
- hardware problems of technology;
- confidentiality and security;
- distrust of the private sector outsourced public services.

3.2 Comparative Analysis of e-Democracy in Ukraine and Canada

In the UNO ranking for the development of e-government in the world, Canada ranked 11th with an index of 0.8430. According to IDS, 61% of Canadians believe that e-services offered by the state are effective.

We compare the stages of implementation of e-government in Canada (Table 2) and Ukraine (Fig. 8).

Table 2 Stages of e-government implementation in Canada

Stages	Period	Description
1st stage	1994–1997	The Information Highway Program was launched in Canada
2nd stage	1997–1999	The government supported the gradual introduction of e-government in Canada
3rd stage	1999—2001	Since October 1999, following the Canadian Parliament, e-government has become a key component of Canada's government strategy
4th stage	2001–2005	Since the beginning of 2001, all documents, regulations, information on courses and tenders have been posted on the Internet
5th stage	2005–2015	Since 2005, the GovernmentOnLine (GOL) program has provided Canadian citizens with comprehensive information and all necessary services
6th stage	2015—till today	All government services have been introduced over the Internet since 2005

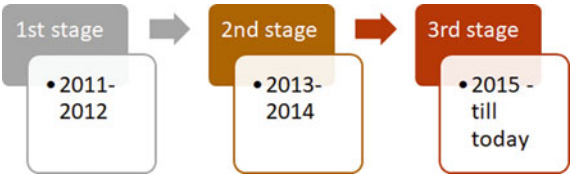

Fig. 8 Stages of e-government implementation in Ukraine

If we analyze the stages of implementation of e-government in Ukraine and Canada, we can conclude that in Canada this process began 17 years faster than in Ukraine. This is the fact that e-government is at a high level in Canada, and in Ukraine, it is just beginning to improve.

3.3 Electronic Democracy in China

The e-commerce market is $562.66 billion. 33% of purchases come from transportable devices, 67% by desktops. The average age of an online purchaser is 25 years old. Online shopping in China is the most dynamic online activity.

The Chinese e-commerce market is the largest in the world. For 20 years, receiving rapid development, it has had an essential role in the growth of the national economy, the development of entrepreneurship and innovation, the fight against poverty.

E-commerce is especially relevant in countries where some goods are unreasonably expensive or not on the market. Undoubtedly, in China, with its ever-increasing standard of living, the potential of cross-border e-commerce has great potential. China is preparing to become a hub for the largest Internet companies. China now

has nine of the world's 20 largest Internet companies, and the United States has 11. Five years ago, there were only two companies in China.

The main tasks in the field of e-commerce to be solved by China in 2016–2020 are to improve quality characteristics, deepen its integration into traditional industries, develop factor markets for e-commerce, including labor markets, technology, capital and land, and improve a system that would enable all segments of the population to benefit from the rapid development of e-commerce.

3.4 Electronic Democracy in the United States

The e-commerce market in the United States is 349, 06 billion dollars. 13% of purchases come from tablets, 15% from smartphones, and 72% from desktops. As a result, the United States shoppers buy goods and services by computers and less be means of portable devices. 72% of small and medium enterprises do not trade online.

Thanks to mobile, sales of which grew by 55% in 2018, e-commerce in the United States in 2018 grew by 16%. Annual turnover exceeded $500 billion.

The most prominent players in the US e-commerce market are Wal-Mart Stores and Amazon. Wal-Mart Stores sales from the website for the last fiscal quarter increased by 67% compared to last year. In the second quarter, Amazon's net sales in North America reached $22.37 billion, which is 26.6% higher than last year—$17.67 billion.

Interesting facts: SPS (US Post) in January 2019 was preparing to process 1 million returns per day; 10% of Christmas purchases in the US return; 80% of US mobile users use voice search to search for local businesses; 50% of them visit the store during the day, and 18% of these local searches turn into sales; more than half of US states have already introduced a tax on online sales at the place of purchase—or will do so in 2019.

3.5 Electronic Democracy in Germany

The e-commerce market is 74, 46 billion dollars. 11, 5% of purchases come from tablets, 16, 2% from smartphones, and 72, 3% from desktops. Germans often open e-mails in the morning. Amazon and Otto account for half of the online sales.

86.2% of the population has access to the Internet. This is a high figure, but it is an order of magnitude lower than in some developed European countries, such as the Netherlands or the United Kingdom. However, with around 60 million Germans using the Internet, Germany is an attractive e-commerce market. Smartphones in the country are 64% standard, almost the same as the average in Western Europe.

60% of the population of 49, 5 million Germans prefer to shop online. Fourteen million have bought goods at least once from foreign online retailers. In terms of online sales, which amounted to almost 80 billion dollars in 2014, the country is the

fifth largest e-commerce market globally. Of great importance for German consumers is the ability to return the product. Germany shows a very high percentage of returns is up to 50% of all orders are sent back to the store. Consequently, for customers to be satisfied, it is essential for online stores operating in Germany to consider a system of returns and arrange free delivery.

Germany is one of the most attractive European countries to develop e-commerce. As in the UK, consumer confidence remains a priority. When working in this country, special attention should be paid to the security of electronic payments, clear organization of logistics processes, and, finally, high-quality customer service. Among the obstacles that may arise is the problem of language barriers (specific dialects of different regions of the country), the complexity of the organization of legislative and tax systems, and strict compliance with privacy laws.

3.6 Electronic Democracy in France

The e-commerce market is 42, 62 billion. 8.1% of purchases come from tablets, 11.1% from smartphones, and 80, 8% from desktops. Only 68% of French people use the Internet. 19% of purchases are made on foreign sites.

E-commerce in France is growing rapidly—by 11% per year. The e-commerce market, valued at almost 57 billion dollars, is the third-largest in Europe. This makes France an excellent place to develop e-commerce. One-fifth of online purchases are made using a mobile phone. Self-pickup of online goods purchased in France is especially popular. Thus, 26% of all purchases are made online.

France is one of the largest e-commerce markets in the world. In general, the French prefer to use credit cards as the most convenient means of payment. The most promising segment for work here is tourism is the offer of goods and services that create comfortable conditions for travel. However, foreign entrepreneurs should keep in mind that the distinguishing feature of the French consumer is loyalty to the national producer and goods of local regional production.

3.7 Electronic Democracy in Switzerland

Recent Switzerland has been a prosperous nation and has one of the most powerful banking communities globally. Given Switzerland's highly developed banking sector, it is not surprising that bank accounts are very common among the local population. Almost 100% of Swiss people over 15 years old have own bank accounts. The credit cards are also popular. They are used by 54% of the population. At the same time, the Swiss are not prone to large purchases on credit.

The amount of Swiss Internet users increased from 79 to 87% of the total population in the period of 2008–2014 years. Given the relative complexity of creating new infrastructure due to the peculiarities of the Swiss landscape, this figure is impressive.

The distribution of smartphones is quite wide—they are in 73% of the population. E-commerce in Switzerland grew by 16% in 2014, reaching 12, 7 billion dollars. Swiss, like Austrians, spend a lot. The average online shopper leaves 3190 dollars a year in online stores. The most prominent players in online retail are Amazon, Nespresso, Zalando, LeShop. But the Swiss retailer Digitec holds the lead.

3.8 Electronic Democracy in South Korea

The e-commerce market is 36, 76 billion dollars. 1% of users buy the goods using tablets, 50% smartphones, and 49% of users buy from computers. South Korea users have the highest speed of the Internet in the world. On average, there are up to five credit cards per South Korean. For contrast, everybody in the United State has an average of two cards. South Koreans buyers like sales in online shops and promotions. And the fastest internet-only promotes online shopping. Unlike the Germans, who like to shop in the morning, and the British, who prefer evening shopping, South Koreans can be unequivocally attributed to the midnight, who sits in front of the screen late. South Koreans often buy American goods. This is probably reason that local South Korean goods are nine times extra expensive than foreign companies.

3.9 Electronic Democracy in Australia

Since 2001, the United Nations has been preparing a report on the development of e-government in the world. The latest such report is the United Nations e-Government Survey. The report considers the following indicators which presented in Fig. 9.

These indicators are not a complete list of indicators assessed by the UN, but at the time of writing, the full list of indicators has not been officially published.

Thus, according to preliminary data published by the UN, Australia has a fairly high position among other countries.

Regarding to the e-government development index, Australia ranks 8th, behind some countries in fact due to lack of public awareness and lack of use of electronic services and telecommunications by citizens. According to the online services index, Australia shares 5th place with Spain, but in some respects, such as access to services, it is even ahead of Korea's leader.

Australia lost most of its telecommunications infrastructure development index figures due to too few dedicated Internet access lines and telephone lines.

In fact, according to a preliminary estimate by United Nations experts, in 2010 Australia ranked second in the world in the index of participation in e-government, led by South Korea.

Australia, like Canada, has been developing elements of e-government and support systems since the 1980s. Attempts to combine different data (registration, evaluation, cadastral, etc.) led to the creation of the Land Information System, Australia's first

Fig. 9 Indicators of the United Nations e-Government survey

electronic system, and pushed the continent's governmental and non-governmental organizations to develop e-government. It is from this point on that Australian government organizations develop and implement their web representations.

Since 2004, responsibility for the development and delivery of e-government services has been transferred to the Special Minister and the Australian Government Information Management Office (AGIMO), established in 2004 as part of the State Department of Finance and Deregulation.

This state body is still dealing with the development of e-government and e-services.

Since the mid-90s of the twentieth century. The Australian government is working hard to ensure the regulatory, political and economic environment for e-services.

During this time, a large number of projects were implemented. A single Australian government e-services site (http://australia.gov.au/) has been developed and implemented, which is still being developed, filled with public services and links to various related services (shown in Fig. 10). This site should eventually become a starting point for finding any government e-service.

The main authority for the development of ICT and e-government and their regulatory framework was delegated by the Australian government to the Australian Department of Finance and Deregulation (roughly similar to the Ministry of Economy of Ukraine), the Department of Finance and Deregulation, the Australian Government Information Management Office (AGIMO). This public authority of Australia creates the regulatory framework, government programs, involves government and local government in the development of e-government.

The most important acts of the Government of Australia governing the activities of the state in the field of information and communication technologies include:

Fig. 10 The Australian governmental site of electronic services

- 1992 Law on Dedicated Communication Channels Law regulating the development of national data transmission networks;
- Law of 1997 on Telecommunications regulates the general principles of functioning of information and communication technologies and directions of their development;
- The Financial Management and Accounting Act 1997, which regulates public spending on the development of information and telecommunications technologies in Australia;
- Law of on Provision of Public Services;
- Normative act of On Spam;
- Program of the Code of Electronic Marketing Practices;
- Public Procurement Programs Guidance on Complying with the Policies of the Commonwealth in Procurement;
- Government programs and strategies for the e-government development and ICT.

E-government services in Australia are provided at three levels: federal (national), state and local. But most services permeate all these levels, from the lowest to the highest, allowing the citizen to receive the required service regardless of the level from which he made the request. All services, regardless of level, are divided into information (citizen finds the necessary information on public websites and completes use of sites), interactive (citizen finds necessary information and makes inquiries to public authorities) and transactional (citizen finds necessary information and orders paid or free public electronic service).

Depending on the levels at which the service is provided, citizens prefer different types of requests. Using the federal level of services, citizens often use the following services: electronic taxation, electronic address search, ordering a passport online, electronic medicine, job search.

The state, for its part, is trying to develop all areas of e-government. It is worth noting that the most significant and used at the national level are the projects of various public authorities in Australia.

The State Department of Industry, Tourism and Raw Materials has created the portal The Business Entry Point to help do business. At any level (federal, state or local), legal entities have access to the necessary information and services.

The State Department of Human Services has created the large and most widely used portal The Customer Services Online (Centrelink) to provide a wide variety of electronic services in various sectors of the economy to individuals and legal entities. From is a national portal, but most transactions are carried out at the state level. The Australian Department of Finance and Governance has set up a portal exclusively for tenders and public procurement, The Australian Government Tender System (AusTender). The Federal Court of Australia has created the electronic system The Electronic Filing System (eFiling). This project is currently an integral part of Australia's e-government e-justice industry, etc.

Separately, I would like to note that the State Agency for Information Management of Australia (AGIMO) establishes certain principles (in different areas and structures) of the functioning of public information and communication technologies, the most important of which are such as:

- Business Continuity—a project designed to develop criteria and strategies for the continuous provision of services by public authorities, even if the entire information and communication system of Australia fails;
- Open Source Software is free software.
- A large number of Australian authorities already use such software;
- Public Information Protection (Fedlink)—an innovative and high-speed virtual private network (VPN) that allows public authorities to quickly transmit information through a secure environment using the Internet and public secret channels. FedLink uses existing government Internet channels and uses them to create more secure state Intranet channels;
- Intra Government Communications Network (ICON)—a specialized government network in Canberra;

Internet Protocol version 6 (IPv6)—was designed to increase the amount of space for IP addresses. This protocol has certain advantages:

- increased security, automation and simplification of many technical processes;
- Australian Government Domain Administration—the state information domain administration and local government form the gov.au domain management policy;
- Agency Website Search Service—fast and convenient search of websites of public authorities;
- Data Centers—government support for the creation of state data banks and others.

4 Conclusion

The most common tools of e-democracy used today at the countrywide and local levels are e-consultations, e-petitions, and e-appeals. Resources have also been created for the publication of data sets in the open data form.

Application of up-to-date, innovative methodologies and technologies, sharing economy, promotion of the method of Big Data processing, regulatory regulation of the principles of digital compatibility by default, as well as the use of promising forms of tasks organization and e-government development projects, including public–private partnership, will contribute to the establishment of an effective e-government system in Ukraine to meet the safeties and requirements of persons and legal entities, and stimulating the country social and economic development.

The main advantages of e-democracy of countries are shown in Fig. 11.

E-government aims to develop e-democracy to achieve European standards of quality in the provision of e-government services, openness, and transparency of government for citizens, society and business. The system of interrelated objectives in the relevant government policy is shown in Fig. 12.

The use of e-government tools contributes to:

- solving the main problems of the Ukrainian state: non-transparency, secrecy, high level of corruption of public authorities;
- formation and improvement of mechanisms of decentralization, democratic control, and citizens contribution in the development and implementation of public policy;
- restoring citizens' trust in institutions and public officials.

The main advantages of e-democracy in both countries:	• a significant reduction in the cost of democratic procedures;
	• reduction of costs for interactive forms of interaction with citizens, which allows public authorities to more fully take into account the views of different social groups in decision-making;
	• involving citizens in decision-making at an earlier stage and in a closer form;
	• involvement of social groups of citizens with disabilities, who find it difficult to ensure their public rights through traditional forms of democratic participation;
	• strengthening citizens 'trust in the state due to the image functions of new communication channels, creating the illusion of citizens' participation in decision-making.

Fig. 11 The main advantages of e-democracy of countries

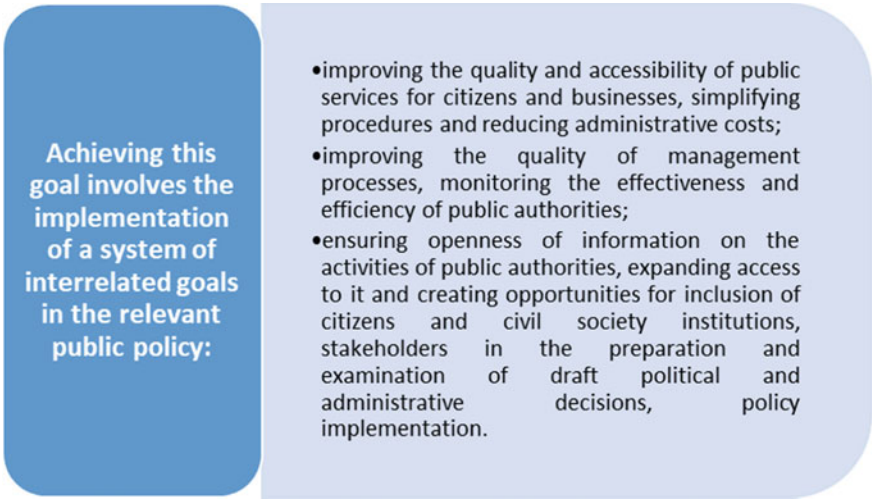

Fig. 12 The system of interrelated objectives in the relevant government policy

E-democracy in Ukraine is far from the same level as in Europe. Ukraine is taking successful steps to improve the public administration system, increase the competitiveness, social and economic growth of the country.

References

1. Addo, A.: Controlling petty corruption in public administrations of developing countries through digitalization: an opportunity theory informed study of Ghana customs. Inf. Soc. **37**(2), 99–114 (2021)
2. Barkov, A., Sokolov, A., Kiselev, A.: The structure of the e-state and public administration at the digital age. EDP Sci. SHS Web of Conf. **109**, 01008 (2021)
3. Kryvinska, N., Kaczor, S., Strauss, C.: Enterprises' servitization in the first decade—retrospective analysis of back-end and front-end challenges. MDPI J. Appl. Sci. **10**(8), 2957 (2020). https://doi.org/10.3390/app10082957
4. Pomytkina, L., Podkopaieva, Yu., Hordiienko, K.: Peculiarities of manifestation of student youth' roles and positions in the cyberbullying process. Int. J. Modern Educ. Comput. Sci. **13**(6), 1–10 (2021). https://doi.org/10.5815/ijmecs.2021.06.01
5. Kryvinska, N.: An analytical approach for the modeling of real-time services over IP network. Elsevier Trans. IMACS J. Math. Comput. Simul. **79**, 980–990 (2008). https://doi.org/10.1016/j.matcom.2008.02.016
6. Onyshchuk, O., Fedushko, S., Syerov, Yu.: Comparative analysis of E-democracy implementation in Ukraine and Switzerland. In: CEUR Workshop Proceedings. Proceedings of the International Workshop on Cyber Hygiene (CybHyg-2019). CEUR, vol. 2654, pp. 628–629 (2019). http://ceur-ws.org/Vol-2654/paper49.pdf
7. Daud, I., Sumaryana, A., Nurasa, H., Susanti, E.: Electronic digital indentification (E-KTP) as an element of E-democracy in Indonesia. KnE Soc. Sci. 776–783
8. Gupta, D., Biswas, A.: The Institutionalization of e-democracy: challenges, risks and future directions in an Indian context. JeDEM-eJournal eDemocracy Open Gov **13**(1), 127–143 (2021)

9. Kassen, M.: Open data governance in Sweden: government data transparency in the context of social democracy. Open Data Governance and Its Actors, pp. 97–132. Palgrave Macmillan (2022)
10. da Silva Neto, V., Chiarini, T.: Technological progress and political systems: non-institutional digital platforms and political transformation. Technol. Soc. **64**, 101460 (2021)
11. Kuzminykh, I., Yevdokymenko, M., Yeremenko, O., Lemeshko, O.: Increasing teacher competence in cybersecurity using the EU security frameworks. Int J Mod Educ Comput Sci (IJMECS) **13**(6), 60–68 (2021). https://doi.org/10.5815/ijmecs.2021.06.06
12. Lyubimov, A., Cherny, V.: The evolution of globalism: from computerization to e-democracy and the digital economy of knowledge. Autom. Doc. Math. Linguist. **55**(2), 39–45 (2021)
13. Rascão, J.: Freedom of speech, privacy, and ethical and social responsibility in democracy in the digital age. Int. J. Risk Conting. Manag. (IJRCM) **10**(3), 34–83 (2021)
14. Dowling, M.: Foreign interference and digital democracy: is digital era governance putting Australia at risk? Aust. J. Polit. Sci. 1–16 (2022)
15. Jeong, B., Kim, S.: NPO/NGO education in public administration in South Korea. J. Public Nonprofit Aff. **7**(2), 173–191 (2021)
16. Peters, B.G.: Studying public administration in authoritarian regimes. Asia Pac. J. Public Adm. **43**(1), 1–5 (2021)
17. Samy, M., Anis, W., Abdel-Hafez, A., Eldemerdash, H.: An optimized protocol of m2m authentication for internet of things (IoT). Int. J. Comput. Netw. Inf. Secur. **13**(2), 29–38 (2021). https://doi.org/10.5815/ijcnis.2021.02.03
18. Kryvinska, N., Bickel, L.: Scenario-based analysis of IT enterprises servitization as a part of digital transformation of modern economy. MDPI J. Appl. Sci. **10**(3), 1076 (2020). https://doi.org/10.3390/app10031076
19. Smyrnova, I., Akimov, O., Krasivskyy, O., Shykerynets, V., Kurovska, I., Hrusheva, A., Babych, A.: Analysis of the application of information and innovation experience in the training of public administration specialists. Int. J. Comput. Sci. Netw. Secur. **21**(3), 120–126 (2021)
20. Pawade, D.: Analyzing the impact of search engine optimization techniques on web development using experiential and collaborative learning techniques. Int. J. Mod. Educ. Comput. Sci. (IJMECS) **13**(2), 1–10 (2021). https://doi.org/10.5815/ijmecs.2021.02.01
21. Alakbarov, R.: Challenges of mobile devices' resources and in communication channels and their solutions. Int. J. Comput. Netw. Inf. Secur. (IJCNIS) **13**(1), 39–46 (2021). https://doi.org/10.5815/ijcnis.2021.01.04
22. Demir, K.: E-participating decision-making mechanism in the public administration system: example of E-government application. In: Research Anthology on Cross-Disciplinary Designs and Applications of Automation, pp. 214–235. IGI Global (2022)
23. Mabi, C.: Civic tech" and "digital democracy" to "open up" democracy? Reseaux **1**, 215–248 (2021)
24. Lindner, R., Aichholzer, G.: E-democracy: conceptual foundations and recent trends. In: Hennen, L., van Keulen, I., Korthagen, I., Aichholzer, G., Lindner, R., Nielsen, R. (eds.) European E-Democracy in Practice. Studies in Digital Politics and Governance, pp 11–45. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-27184-8_2
25. Prastya, D., Nurmandi, A.: A bibliometric analysis of E-democracy on government research. Jurnal Ilmiah Mimbar Demokrasi **20**(2), 71–80 (2021)
26. Kapsa, I.: The legal basis of citizen electronic participation in Poland. Przegląd Prawa Konstytucyjnego **6**(64), 431–438 (2021)
27. Rascão, J.: Social networks and well-being in democracy in the age of digital capitalism. In: Reviving Businesses with New Organizational Change Management Strategies, pp. 71–109. IGI Global (2021)
28. Semenova, K.: The role of public administration science in increasing civic engagement in Ukraine. Krakowskie Studia Małopolskie **29**(1), 95–111 (2021)
29. Avgerou, C.: Information systems in developing countries: a critical research review. J. Inf. Technol. **23**, 133–146 (2008). https://doi.org/10.1057/palgrave.jit.2000136

Development of a Web Application for Electronic Banking

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Abstract The report presents a model of a web application for the bank. Definitions of electronic banking and on-line banks have been included, legal bases that must be followed in Poland in this field, and as regards this the problems that we have to solve and the challenges we face when we want to design and write such an application. A brief history of electronic banking and the likely direction of its future development are presented. The application model itself contains a description of its functionality along with how to build the program. The application testing process was also presented. The aim of the work is to pose both problems business and programming that can be encountered and to find a way to solve them at the design stage and then writing the application. The summary contains our observations and their discussion.

1 Introduction

The revolution in information technology changes every aspect of human life, including the banking sector. IT achievements contribute to the rapid development and commercialization of many modern forms of customer service. This greatly facilitates and speeds up their implementation. Nowadays, IT is the driving force of business and can be used to increase competitive advantage, and electronic banking can be considered the fastest growing financial sector. Generally available, high functionality and simplicity of using such solutions means that we reach for them more and more often. Electronic banking has allowed minimizing costs by giving up many fees for services that customers can perform themselves. Not only banks, but also

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customers benefit from it. They can freely use the bank's services, being anywhere; all they need is Internet access.

1.1 Legal Foundations of Banking in Poland

At the outset, it should be noted that every banking institution that provides not only "fixed-line" services, but also electronic services functions in a certain environment and must meet certain conditions set by that environment.

Each bank operates in an external environment. His activities are evolving in line with trends in the domestic and global economy. The conditions for banking activities are determined primarily by institutional changes (determined by the state and legislation) and functional changes (shaped by the market).

Institutional conditions for banking operations are included in external conditions. Banks have no direct impact on this type of condition. They are mainly reflected in applicable legal regulations [1]. The most important acts regulating banking activity in Poland include: the

- Act of 29.08.1997 Banking Law (Journal of Laws No. 140, item 939, as amended), the
- Act of 29.08.1997 on the National Bank of Poland (Journal of Laws No. 140, item 938, as amended), the
- Act of 21.07.2006 on financial market supervision (Journal of Laws No. 157, item 1119, as amended), the
- Act of 14.12.1994 on the Bank Guarantee Fund (JournalLaws offrom 1995 No. 4, item 18, as amended), the
- Act of 29.08.1997 on mortgage bonds and mortgage banks (Journal of Laws No. 140, item 940, as amended), the
- Act of December 7, 2000 on functioning of cooperative banks, their association and affiliating banks (Journal of Laws No. 119, item 1252, as amended),
- Act of 14.03.2003 on Bank Gospodarstwa Krajowego (Journal of Laws No. 65, item 594, as amended), 22 Part I. Banking system
- Act of July 20, 2001 on consumer credit (Journal of Laws No. 100, item 1081, as amended),
- Act of September 12, 2002 on electronic payment instruments (Journal of Laws No. 169, item 138) 5 as amended).

1.2 Definitions

Electronic banking is a form of service that banks offer. It consists in enabling the customer to access his bank account through various electronic devices (e.g.

computer, ATM, telephone, terminal) and telecommunications connection (e.g. telephone line, cable network). Electronic banking services are characterized by the fact that there is no direct contact between the client and a bank employee [2, 3].

Electronic banking can be divided into a number of categories, among others by:

- type of clients—retail/corporate,
- communication (distribution) channel—internet, telephone, mobile, terminal,
- access level,
- model mode [4].

For the purposes of this documentation, we will base ourselves on the second division.

- Internet banking can be characterized as such a part of electronic banking services that is carried out using the public telecommunications network Internet, without the distinction between means of access and forms of banking (including also services of traditional banks implemented via the network). Internet banking as an instrument of electronic banking is an alternative distribution channel in relation to the branch—the banking branch. Online banking uses the network to provide banking services [5–7]. The most important criterion that distinguishes online banking from others is that its users use banking services via standard web browsers, rather than using dedicated software issued by the bank and installed on users' computers [8].
- Telephone banking can be characterized as the possibility of using the banking offer using a landline or mobile phone. In a more developed form, this communication can take the form of a contact center. Such a contact center may contain all possible connections, not only telephone but also fax, e-mail, chat or made using VoIP [9].
- Mobile banking can be defined as the use of banking services using mobile devices, i.e. smartphones or tablets. Such banking is referred to as m-banking. It should be noted that for this type of solutions banks usually use specially prepared websites in accordance with the design technique, so that the appearance or arrangement of elements automatically adjusts to the size of the device's display, the so-called Responsive Web Design (RWD). Mobile applications are another solution made available by banks. As in the case of other mobile applications, also in this 1 they allow better use of the communication possibilities provided by mobile devices. Another important element is that mobile applications are more suited to a different way of using the device—by selecting elements using the user's finger or e.g. stylus, not a computer mouse.
- Terminal banking is a type of banking that includes electronic devices such as ATMs and electronic terminals for accepting payment cards (EFT–POS) [4].

1.3 Electronic Banking Yesterday and Today

The Polish banking sector has already boomed for stationary bank branches. Today, traditional branches are gradually being replaced by services offered by banks on the Internet and on mobile devices [10]. Only 20 years ago the banking world looked completely different. The first electronic banking services in Poland were offered in the early 90's and they took the form of ATMs. It was the so-called terminal banking, which offered the possibility of using payment cards. At the same time, along with changes in the Polish banking sector and its dynamic development, banks developed customer service through the hotline. Instructions were made to the bank employee. At the end of the 90 s, the first banking website was launched, and in 2000 the first Internet bank was created. Since then, the number of internet banking users has increased 47 times over the next four years. The period of the first decade of the twenty-first century can therefore be described as the most dynamic development of electronic banking services. Today, the structure of electronic banking is much more complex. This solution is becoming more and more popular. Customers receive a number of options to use their account and banking products without visiting the outlet. The area, which is observed in the intensive development include mobile banking. Mobile applications designed for smartphones and tablets ensure that the entire bank remains within range of the mobile device. We can make transfers from it, pay for purchases, check where the nearest ATM or bank branch is, and even make the so-called phototransfer. The growing interest in this method of communication with the bank is confirmed by data. The PRNews.pl report shows that at the end of 2015 the number of mobile banking users exceeded 5.7 million, which means that as many as 2.3 million users of this channel came in during the year [11].

1.4 On-Line Banking

The countries with the highest percentage of customers using electronic banking are the United States and the Scandinavian countries (e.g. Sweden or Finland). In the USA, there is a very clear tendency to establish exclusively internet banks, as well as to "virtualize" as many of their products as possible and to carry out operations by traditional banks. Also in Europe only internet banks operate, however this trend is not as strong as in the USA [12]. It was in the United States that the first bank in the world was founded, which bases its distribution only on the Internet. It was Security First Network Bank. Although the idea was skeptical at first and doubted about the security of the transaction, the time of online banking came and began to develop dynamically ever since. On the first anniversary of operations, about 7,000 accounts were opened and over 20 million dollars were deposited.

An average internet banking user uses this service mainly to have current information about his account, account status and transaction history, and to be able to make transfers without visiting the bank. That is why internet-only banks started to

be created. In Poland, examples of such banking are mBank, Inteligo and VW Bank Direct. The accounts in them are serviced only via the Internet and telephone.

The on-line feature of banks is the fact that keeping an account on the part does not require the involvement of people and on the part of the client to use any additional software. The IT system fully controls the correctness of the client's operations. Lack of branches is also a great way to reduce housing costs and employment of employees. They can offer services without charging a commission.

1.5 Future Banking

The expectations of electronic banking customers focus mainly on convenience and security [13, 14]. These preferences—in combination with competition fintech and new regulations, such as the EUPSD2 directive—are forcing banks to develop digital banking services. In a few years it will be based mostly on new technologies, such as artificial intelligence, machine learning and big data, as well as the trend of open banking. It means that access to the financial market will be gained by new, innovative entities that will be able to offer customers better tailored products and services. It is expected that in the future banks will widely use the latest digital technologies, machine learning, advanced analytics and artificial intelligence. Modern banking clients will primarily use self-service channels in which they will be served by robots and vending machines using the latest digital technologies [15].

The client of the future bank wants the tools made available to him to be very easy to use from any device and ready for use whenever he needs them. 100% security of data and funds on the personal account is also key. Biometry is a natural answer to these demands. The banking sector uses it today, but at a very basic level. Some banks bravely test face, eye and voice recognition biometrics. However, for these methods to be used on a large scale, it is necessary to create a system that could accommodate biometric data of millions of Poles. This is a great field for programmers and visionaries, especially those fascinated by the Big Data idea. Biometrics is definitely the direction in which the banking sector will go. First of all, it is a great convenience in accessing your own funds.

The bank in the near future will no longer focus only on financial services. We expect to introduce such functionalities that we will be able to use when dealing with every day, even mundane matters. The bank will provide us with a virtual assistant. Such an assistant, launched from a mobile device, will help us organize life. Such an assistant, launched from a mobile device, will help us organize life. You broke your laptop and urgently need a new device? Have a virtual bank assistant who, after analyzing your account balance, will offer you several models at a good price, and after confirmation, will order a laptop with delivery to your home or office. The virtual banking assistant knows exactly where you usually shop and what you spend your money on. For example, it can analyze the frequency of fuel expenditure and inform you in advance which station in the city currently has the best prices.

The banking of the future will undoubtedly be focused on maximizing the path that the consumer must follow from the moment of purchasing intentions, to complete the transaction. Customer service will change in the bank of the future. Services will be prepared practically on an ongoing basis and will be closely correlated with our financial situation, shopping choices or even a period of the year [16].

1.6 Cryptocurrencies, Blockchain—History, Definitions, Application

When analyzing the issue of electronic banking, one should also consider the topic of electronic currency.

The idea of having a digital currency is not a new one. Prior to cryptocurrencies, many attempts at creating one have taken place. The main issue most of them were facing, was the double spending problem. A digital asset somehow needs to be usable only once to prevent copying it and effectively counterfeiting it.

Over 10 years before cryptocurrencies, the concept had been introduced by computer engineer Wei Dai. In 1998, he published a paper where he discussed "B-money". He discussed the idea of a digital currency, which could be sent along a group of untraceable digital pseudonyms. That same year, another attempt by the name of Bit Gold was drafted by blockchain pioneer Nick Szabo. Bit Gold equally looked into creating a decentralized digital currency. Szabo's idea was spurred by inefficiencies within the traditional financial system, such as requiring metal to create coins and to reduce the amount of trust needed to create transactions. While both were never officially launched, they were part of the inspiration behind Bitcoin [17].

A cryptocurrency is a digital or virtual currency that is secured by cryptography, which makes it nearly impossible to counterfeit or double-spend. Many cryptocurrencies are decentralized networks based on blockchain technology—a distributed ledger enforced by a disparate network of computers. A defining feature of cryptocurrencies is that they are generally not issued by any central authority, rendering them theoretically immune to government interference or manipulation [18].

In merriam-webster, the formal definition of cryptocurrency indicates: any form of currency that only exists digitally, that usually has no central issuing or regulating authority but instead uses a decentralized system to record transactions and manage the issuance of new units, and that relies on cryptography to prevent counterfeiting and fraudulent transactions [19].

How Cryptocurrency Works: Cryptocurrencies are systems that allow for the secure payments online which are denominated in terms of virtual "tokens," which are represented by ledger entries internal to the system. "Crypto" refers to the various encryption algorithms and cryptographic techniques that safeguard these entries, such as elliptical curve encryption, public–private key pairs, and hashing functions. Types of Cryptocurrency: The first blockchain-based cryptocurrency was Bitcoin, which still remains the most popular and most valuable. Today, there are thousands of

alternate cryptocurrencies with various functions and specifications. Some of these are clones or forks of Bitcoin, while others are new currencies that were built from scratch [20].

Bitcoin is a new currency that was created in 2009 by an unknown person using the alias Satoshi Nakamoto. Transactions are made with no middle men—meaning, no banks! Bitcoin can be used to book hotels on Expedia, shop for furniture on Overstock and buy Xbox games [20].

When Bitcoin first gained popularity, the idea of the digital economy aroused people's imagination like never before. Cryptocurrencies—and the blockchain technology that follows them—were to introduce a new, more open world of transactions and trade. Free from ubiquitous regulations and intermediaries, the units were to regain the financial system at the hands of banks and governments. People would make payments, buy and sell completely anonymously without the supervision of financial institutions, completely separating themselves from their current structure. In theory, this would be a great idea indeed. However, as often happens, in reality we are really far away from a completely decentralized, digital economy.

Governments and financial institutions will never allow their means of payment to become obsolete and out of service, and transactions completely impossible to trace. The economic and security stakes are too high for them: loss of taxes, collapse of the world economy or potential threat to society from criminals and terrorists operating under the anonymity coat. These are one of the reasons why traditional banks will not cease to exist. However, to keep up with technological changes and maintain their position on the market, they will have no choice but to start implementing blockchain technology into their structures of operation.

Most people are accustomed to using banks and prefer to keep their money in secure bank accounts than invest them in unstable, newly created cryptocurrencies. Financial institutions use this long history of their clients' trust in their services to create their own asset-backed digital currencies. In addition to creating their own stable cryptocurrencies, financial institutions will also put a lot of money into the development of blockchain technology. For example, JPMorgan and other large enterprises are already investing in the Enterprise Ethereum Alliance to define and define the future of blockchain and its impact on the global community [21].

Central to the appeal and functionality of Bitcoin and other cryptocurrencies is blockchain technology, which is used to keep an online ledger of all the transactions that have ever been conducted, thus providing a data structure for this ledger that is quite secure and is shared and agreed upon by the entire network of individual node, or computer maintaining a copy of the ledger. Every new block generated must be verified by each node before being confirmed, making it almost impossible to forge transaction histories.

Many experts see blockchain technology as having serious potential for uses like online voting and crowdfunding, and major financial institutions such as JPMorgan Chase (JPM) see the potential to lower transaction costs by streamlining payment processing. However, because cryptocurrencies are virtual and are not stored on a central database, a digital cryptocurrency balance can be wiped out by the loss or destruction of a hard drive if a backup copy of the private key does not exist. At the

same time, there is no central authority, government, or corporation that has access to your funds or your personal information [21].

One of the solutions that may be of interest to financial institutions in the context of blockchain are interbank and international transfers. We currently use the SWIFT system for this purpose, which has been around for over 45 years. It supports over 15 million messages … per day! In addition, the system sends information about transfer orders, not the transfers themselves. Therefore, banks must have accounts in other banks. Financial institutions will strive to optimize the costs of data processing and more efficient service for their clients. For this purpose, they can use blockchain technology, introducing a system that will have its own monetary base (or not) and will be used for interbank settlements. Also without a monetary base, a system can be created that supports transactions requiring the modification of data in the network.

Bitcoin and Ethereum ensures anonymity because it is open to the whole group of users. Banking systems are usually closed, so they don't have to take advantage of anonymity. Ultimately, they may have a common billing system that will use the Proof of Authority (PoA) mechanism to reach a consensus. In this way, you can implement a system in which we will have real-time transfers, regardless of whether it is an internal or external transfer—between banks—or even an international one.

Another element that can be used taking into account blockchain is the transaction history. As we know, blockchain history is unmodifiable. This is due to the architecture in which the blockchain is built.

The use of cryptography in blockchain networks makes it possible to identify the client in some way. To order a transaction in the Ethereum or Bitcoin network, we need a wallet. A wallet is nothing but a pair of private and public keys. It is therefore possible to use this solution to identify the customer. To order a cryptocurrency transfer from one account to another, we must sign the transaction with a private key. So we are the only person who can make a transfer from your own wallet. The traditional transfer model does not use a cryptographic signature mechanism, which may change soon.

Another, rather interesting topic, may be the introduction of cryptocurrency support by the banks themselves. Today we can set up an account that supports Polish currency or foreign currency. What if banks make it possible to own a cryptocurrency and pay it with the help of a payment card? Revolut is currently the closest to this option, as it offers a "Converter" in its services. We can, for example, sell or buy cryptocurrencies there [22].

1.7 Types of Cryptocurrencies

Bitcoin was revolutionary because it enabled peer-to-peer payments without requiring trust in either party or a third party like a central bank. Transactions are instead facilitated through the use of blockchain technology.

Blockchain is open source, which means anyone can take the original source code and create something new with it. And developers have done just that,

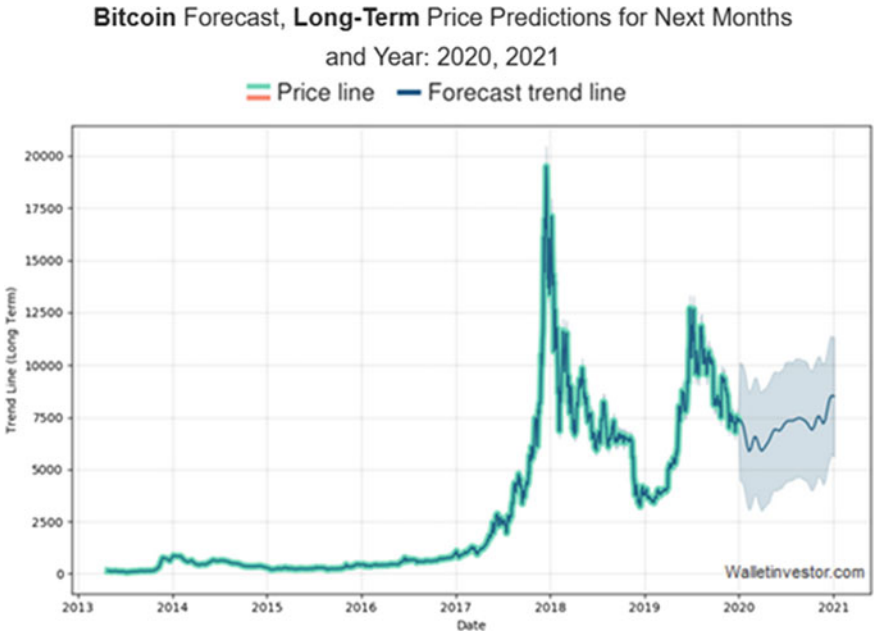

Fig. 1 Long-term price prediction for bitcoin [24]

producing hundreds of alternatives to bitcoin and different applications of blockchain technology to go along with them. These bitcoin alternatives are called altcoins.

There are three overarching types of cryptocurrency:

1. Transactional cryptocurrencies serve as a way to store and exchange value. Examples include bitcoin and litecoin.
2. Cryptocurrency platforms create an infrastructure to build new blockchain application. Ethereum is an example of a cryptocurrency platform built to run smart contracts. Factom allows developers to build secure record-keeping applications.
3. Cryptocurrency applications are built on top of cryptocurrency platforms. Anything from initial coin offerings (ICOs) used to raise start-up funds to things like the 0 × Project, which creates a decentralized exchange for other cryptocurrencies (or anything else) [18] (Fig. 1 and Table 1).

1.8 Forecast for Bitcoin

According to our Forecast System, BTC is a good long-term (1-year) investment*. Bitcoin predictions are updated every 3 min with latest prices by smart technical analysis. Q&A about BTC projections. See Our Other Forecasts at Walletinvestor.com we predict future values with technical analysis for wide selection of digital coins like Bitcoin. If you are looking for virtual currencies with good return, BTC can be a

Table 1 Top 100 cryptocurrencies by market capitalization [23]

#	Name	Market Cap	price	Volume (24 h)	Circulating supply
1	Bitcoin	$132 943 185 596	$7329.25	$25 806 053 806	18 138 712 BTC
2	Ethereum	$14 428 257 241	$132.22	$9 484 235 690	109 123 227 ETH
3	XRP	$8 351 496 056	$0.192707	$1 299 996 130	43 337 903 409 XRP *
4	Tether	$4 117 419 769	$1.00	$29 951 858 309	4 108 044 456 USDT *
5	Bitcoin Cash	$3 886 345 295	$213.51	$2 030 449 596	18 202 513 BCH
6	Litecoin	$2 671 303 730	$41.89	$3 223 600 645	63 775 169 LTC
7	EOS	$2 467 253 217	$2.61	$2 193 891 680	947 094 394 EOS *
8	Binance Coin	$2 122 807 513	$13.65	$158 113 727	155 536 713 BNB *
9	Bitcoin SV	$1 789 173 084	$99,02	$541 175 697	18 068 415 BSV
10	Stellar	$904 891 706	$0.045121	$167 006 851	20 054 779 554 XLM *
11	Tezos	$ 892 354 973	$ 1.29	$ 46 265 650	694 191 974 XTZ *
12	TRON	$890 801 931	$0.013359	$1 080 207 898	66 682 072 191 TRX
13	Cardano	$883 105 996	$0.034061	$29 979 163	25 927 070 538 ADA
14	Monero	$859 793 249	$49.46	$105 286 269	17 383 550 XMR
15	UNUS SED LEO	$843 415 958	$0.843839	$6 660 205	999 498 893 LEO *
16	Cosmos	$805 355 622	$4.22	$1 31 399 641	190 688 439 ATOM *
17	Huobi Token	$679 626 227	$2.82	$139 916 868	241 284 047 HT *
18	Chainlink	$633 490 821	$1.81	$59 427 956	350 000 000 LINK *
19	Neo	$624 450 041	$8.85	$359 194 181	70 538 831 NEO *
20	Ethereum Classic	$519 864 097	$4.47	$803 160 687	116 313 299 ETC
21	USD Coin	$514 689 372	$1.00	$349 751 550	512 984 024 USDC *
22	HedgeTrade	$504 086 179	$1.75	$363 839	288 114 855 HEDG *
23	IOTA	$458 401 449	$0.164920	$5 005 580	2 779 530 283 LITTER *
24	Crypto.com Coin	$441 318 510	$0.034579	$10 081 556	12 762 557 078 CRO *

(continued)

Table 1 (continued)

#	Name	Market Cap	price	Volume (24 h)	Circulating supply
25	Maker	$425 668 105	$425.67	$	3,673,247 1,000,000 MKR *
26	Dash	$397 643 224	$43.00	$231 008 244	9 248 568 DASH
27	Ontology	$333 580 859	$0.523386	$67 340 203	637 351 170 ONT *
28	VeChain	$299 454 474	$0.005400	$63 588 302	55 454 734 800 VET *
29	NEM	$289 603 663	$0.032178	$5 638 683	8 999 999 999 XEM *
30	Basic Attention Token	$269 942 718	$0.190718	$52 394 067	1 415 403 562 BAT *
31	Dogecoin	$255 624 430	$0.002083	$74 942 363	122 742 527 214 DOGE
32	Zcash	$237 261 563	$28.35	$137 976 509	8 368 906 ZEC
33	Paxos Standard	$ 223 224 734	$ 1.00	$ 405 757 470	222 324 468 PAX *
34	FTX Token	$214 880 818	$2.21	$5 967 231	97 128 008 FTT *
35	Decred	$185 338 694	$17.18	$6 429 282	10 786 831 DCR
36	Synthetix Network Token	$184 566 387	$1.18	$199 586	156 372 297 SNX *
37	Qtum	$ 155 138 888	$ 1.61	$ 309 105 660	96 282 876 QTUM *
38	TrueUSD	$152 968 873	$1.00	$232 688 335	152 308 764 TUSD *
39	Ravencoin	$120 213 293	$0.023075	$15 709 358	5 209 580 000 RVN
40	Algorand	$113 272 746	$0.2226018	$44 268 015	501 166 905 ALGO
41	Seele	$110 985 102	$0, 158,644	$38 151 756	699 587 206 SEELE *
42	0x	$109 368 722	$0.180948	$12 639 858	604 421 968 ZRX *
43	OKB	$105 490 441	$2.64	$68 867 915	40,000,000 OKB *
44	Holo	$102 086 489	$0.000631	$7 251 482	161 889 281 920 HOT *
45	Waves	$101 279 754	$1.01	$74 626 854	100 768 474 WAVES *
46	Augur	$100 927 227	$9.18	$8 764 019	11,000,000 REP *
47	Bitcoin Gold	$93 724 569	$5.35	$10 834 941	17 513 924 BTG

(continued)

Table 1 (continued)

#	Name	Market Cap	price	Volume (24 h)	Circulating supply
48	Centrality	$90 38 2 502	$0.084514	$305 981	1 069 442 193 CENNZ *
49	ZB Token	$87 917 294	$0.189768	$65 426 435	463 288 810 ZB *
50	OmiseGO	$87 121 644	$0.621209	$43 458 009	140 245 398 OMG *
51	Nano	$87 085 801	$0,653,560	$2 112 853	133 248 297 NANO *
52	Swipe	$83 503 344	$1,37	$16 280 799	61 135 911 SXP *
53	ABBC Coin	$80 493 664	$0,144,610	$51 071 233	556 626 634 ABBC
54	Molecular Future	$77 254 807	$1,75	$24 302 907	44 141 873 MOF *
55	THETA	$77 029 236	$0,088,488	$1 476 077	870 502 690 THETA *
56	KuCoin Shares	$76 819 032	$0,932,682	$10 028 568	82 363 551 KCS *
57	DigiByte	$68 876 776	$0,005,436	$1 086 585	12 670 524 262 DGB
58	Lisk	$67 692 673	$0,558,275	$1 178 129	121 253 359 LSK *
59	Bytom	$65 410 303	$0,065,247	$7 469 293	1 002 499 275 BTM
60	LUNA	$64 883 367	$0,225,473	$4 204 334	287 765 804 LUNA *
61	MCO	$64 534 503	$4,09	$15 580 662	15 793 831 MCO *
62	Horizen	$64 472 124	$7,94	$1 167 868	8 118 663 ZEN
63	Enjin Coin	$61 569 639	$0,077,952	$4 947 970	789 837 740 ENJ *
64	BitTorrent	$61 475 722	$0,00,029 0	$82 855 564	212 116 500 000 BTT *
65	Komodo	$59 432 342	$0,505,066	$2 265 728	117 672 516 KMD
66	IOST	$59 173 834	$0,004,925	$22 286 720	12 013 965 609 IOST *
67	Nexo	$58 827 045	$0,105,048	$10 312 958	560 000 011 NEXO *
68	ICON	$57 659 450	$0,112,279	$5 022 508	513 535 961 ICX *
69	Verge	$56 395 607	$0,003,495	$1 580 949	16 134 425 959 XVG

(continued)

Table 1 (continued)

#	Name	Market Cap	price	Volume (24 h)	Circulating supply
70	Bitcoin Diamond	$55 998 779	$0,300,273	$1 309 216	186 492 898 BCD
71	Siacoin	$55 449 516	$0,001,326	$1 460 215	41 817 047 634 SC
72	MonaCoin	$50 203 063	$0,763,781	$713 538	65 729 675 MONA
73	V Systems	$49 929 476	$0,026,416	$1 521 159	1 890 093 937 VSYS *
74	Bytecoin	$49 088 342	$0,000,267	$3462	184 066 828 814 BCN
75	Energi	$48 970 974	$2,01	$451 706	24 419 712 NRG
76	HyperCash	$48 199 427	$1,08	$10 074 372	44 471 496 HC
77	Steem	$44 253 716	$0,124,369	$252 684	355 827 045 STEEM *
78	Zilliqa	$44 207 014	$0,004,512	$5 395 180	9 797 966 793 ZIL
79	DxChain Token	$44 091 868	$0,000,882	$958 276	50 000 000 000 DX *
80	Quant	$43 459 765	$3,60	$1 497 502	12 072 738 QNT *
81	BlockStamp	$41 545 242	$1,59	$465 403	26 163 639 BST
82	BitShares	$41 448 469	$0,015,092	$3 190 743	2 746 410 000 BTS *
83	Single Collateral DAI	$39 332 344	$1,00	$893 849	39 233 009 SAI *
84	Matic Network	$38 725 482	$0,015,192	$31 824 655	2 549 094 192 MATIC *
85	Aeternity	$38 565 850	$0,129,987	$4 402 928	296 689 407 AE
86	EDUCare	$38 518 221	$0,038,518	$2 021 812	1 000 000 000 EKT *
87	Ardor	$38 082 166	$0,038,120	$1 805 674	998 999 495 ARDR *
88	Silverway	$36 775 837	$0,367,758	$340 250	100 000 000 SLV *
89	DigixDAO	$36 510 656	$18,26	$269 505	2 000 000 DGD *
90	Crypterium	$36 435 380	$0,365,381	$104 107	99 718 904 CRPT *
91	STASIS EURO	$35 571 307	$1,11	$868 880	31 979 207 EURS *
92	Electroneum	$35 191 458	$0,003,539	$150 207	9 945 142 645 ETN

(continued)

Table 1 (continued)

#	Name	Market Cap	price	Volume (24 h)	Circulating supply
93	Decentraland	$34 840 577	$0,033,177	$13 052 827	1 050 141 509 MANA *
94	Kyber Network	$34 531 145	$0,203,433	$4 106 941	169 742 005 KNC *
95	Nash Exchange	$33 369 339	$0,921,890	$1 750 914	36 196 678 NEX *
96	MaidSafeCoin	$32 682 604	$0,072,218	$137 997	452 552 412 MAID *
97	SOLVE	$32 536 720	$0,099,372	$202 346	327 424 138 SOLVE *
98	RIF Token	$31 871 449	$0,058,180	$5 490 498	547 806 681 RIF *
99	Status	$31 670 601	$0,009,126	$14 799 446	3 470 483 788 SNT *
100	iExec RLC	$31 070 752	$0,388,041	$746 976	80 070 793 RLC *

profitable investment option. Bitcoin price equal to 7327.340 USD at 2020-01-03. If you buy Bitcoin for 100 dollars today, you will get a total of 0.0136 BTC. Based on our forecasts, a long-term increase is expected, the price prognosis for 2024-12-28 is 12983.40 US Dollars. With a 5-year investment, the revenue is expected to be around +77.19%. Your current $100 investment may be up to $177.19 in 2025 [25].

1.9 Security of the ICT Environment in Banks

To maintain security obligates banks, among others Polish Financial Supervision Authority. One of the objectives of supervision is to ensure the security of funds accumulated on bank accounts (Article 133(1) of the Banking Act). Considering the above, the Polish Financial Supervision Authority, as the state supervisory authority, issues recommendations regarding specific areas of their operations to banks. These recommendations are intended to determine the supervisory expectations regarding the practices used by banks [26]. In the field of ICT network security, the PFSA sent two important recommendations to banks. The first is Recommendation D from 2013. This recommendation applies to the management of areas of information technology and ICT environment security in banks [26]. It replaced the previous recommendation issued in this respect in 2002 [27]. In it, the PFSA defines its expectations towards banks as to activities related to, among others to the strategy and organization of information technology and ICT environment security as well as ICT security management. The content of the recommendation is available on the KNF website: www.knf.gov.pl. The second document related to banking security is the Recommendation on the security of payment transactions carried out on the Internet by banks, national payment institutions, national electronic money institutions and cooperative

savings and credit unions. It was released in November 2015 [28]. It mainly touches on the essence of risks associated with online payments. Particular emphasis was placed on the security of data used to authorize (confirm) operations performed in electronic banking and the security of payment cards issued by banks.

1.9.1 Problems/challenges in Electronic Banking

We have been observing the financial revolution in recent years. The banking world is becoming more and more technical and connected every year. We live in a time when banking is becoming mobile and more convenient. At the same time, we are becoming more and more dependent on the Internet. In extreme cases, this relationship takes the form of addiction.

What is the most important feature of mobile banking applications today? First of all, user experience, secondly user experience and thirdly user experience. The pursuit of maximum simplification of the way of logging in, navigating between tabs, and making and authorizing transactions today guides all developers, regardless of whether they create applications for smartphones, tablets or transaction services.

What major challenges in electronic banking can we mention:

- Personal data protection.
- Transaction security.
- The popularity of electronic banking (around 13 million active clients in Poland) and transaction migration to electronic channels exceeding 90% in some institutions. This popularity means that trust in this channel is also critical from a business point of view [29]. Customers would not be able to turn away from electronic channels and return to the departmental channel in terms of business and process.
- Attacks on mobile and online banking [30] and its clients are becoming increasingly complex. They refer to the specifics of the institution. Existing standard response methods are not enough. They require the use of more and more sophisticated methods in defense—above all affecting the contact points of clients and employees with the external environment. Automation of collection, analysis and integration processes from various data sources regarding suspicious transactions and clients is an undeniable direction. On this basis, it is possible to identify patterns and preventive action to reduce financial losses for the institution and its clients. Exchange of information about incidents and cooperation in preventive, educational and identification cases related to various market players—commercial, administrative and law enforcement agencies—is the only way to achieve the desired results in the endless fight against cybercrime. In matters related to security, competition should not play a major role. Part of this type of requirements for entities operating on this market are already being properly defined by regulators [31].
- Nowadays, banking threats have moved to the Internet. The physical wallet thefts are less and less frequent because everything is done electronically. The threats

that may meet us are viruses that are not really visible when we log in to electronic banking. Viruses try to steal our login or password from us. There is therefore a huge danger that a transaction will be made without our knowledge, to a completely different account number than we assumed. These are the main challenges that arise in electronic banking.

- Phishing, which is widely used on the Internet, is another threat. It consists of impersonating an institution, in this case the bank used by the given user. In this situation, often the customer is not able to see that something else is happening on the electronic banking site than what we usually did. That is why it is worth exercising caution, for example checking if we are on a secure banking page, if there are any messages from banks that did not come before. If you notice something disturbing, it is worth making a call to the helpline to the bank and verify whether the message we received or the site that has changed slightly is actually the result of our bank's activities. We can also regularly check your bank account to see if any transaction not ordered by us has been made [32].
- New generations of clients in banking—challenges for the sector. In the last dozen or so years, the widespread access to the internet, the popularization of smartphones and tablets, and the flourishing of interpersonal interactions through social media have defined new generations of customers—Y (Millennials), Z (iGen) and C (Connected). They are generations that do not know or do not remember the times before "digitization", and frequent changes, especially in the area of technology, are everyday life for them. Thanks to the constant access to the internet and mobile devices, the world has become a global village for them. The youngest generations of customers in the United States and Europe alone account for around 1/4 of the population [32], and the oldest are only 36 years old.

New generations of customers also pose significant challenges to banks:

1. Expect simplicity and convenience known from other industries. New generations no longer compare banks with each other, but expect them to receive the same quality of service and customer experience that their favorite companies offer, not necessarily from the world of finance (e.g., they compare the quality of bank service with the service in their favorite online store). Creating a bank account should be as easy as setting up an email account. It should be online and provide immediate access.
2. They see financial institutions as "complicated". They feel lost in the world of finance. They usually lack adequate financial knowledge and banks speak to them in a difficult language using complex terminology. That is why new generations have a problem with understanding banking products. They do not read regulations or contracts, which is why they express fear of e.g. the fees hidden in them.
3. A visit to a bank branch is not an option (rather). Banking and mobile payments are standard for the new generation. They are not interested in visiting a bank branch, since they can do everything on their smartphone. As a consequence, by 2020, it is expected that as many as 8 out of 10 young will never appear in a bank branch [33]. Still, paradoxically, they still expect contact with their employees.

What, however, definitely sets them apart is the way of communication and the technology they use. Instead of visiting the ward, they prefer remote channels (chat, video, social media) where they communicate comfortably and—when they need it—can talk to a consultant for help or advice.

4. Limited confidence in financial institutions. The lack of trust and loyalty is a particularly important challenge. New generations of customers are looking for an institution that will help them achieve their goals in the most convenient and fast way. For a new consumer, e.g. payment for a service is only a small element of a larger process, which is the fulfillment of his need—the purchase of his dream smartphone or payment for traveling with Uber to the event. I don't care who delivers the product. Therefore, they are extremely open to financial services offered by companies other than banks, e.g. fintechs, which attract them with simple and transparent rules of access to services. As a consequence, e.g. in the US, as many as 73% of Millenials are more interested in financial services offered by Google or Amazon than services offered by banks [34]. An interesting fact is that, in terms of banking products, young customers, paradoxically, do not differ much from previous generations. They are also eager to use personal accounts, credit cards or deposits [35]. It is worth mentioning at this point that technological progress brings significant challenges for banks. Representatives of new generations, accustomed to changes in the field of technology, eagerly reach for such innovations as Virtual Reality (VR) or Internet of Things (Internet of Things). We can therefore assume that in the coming years a change in current customer behavior should be expected. Artificial Intelligence (AI) is particularly interesting in this context. Even today chatbots on Facebook or virtual assistants, e.g. in the Google Allo application, who look like a human in conversation, are becoming increasingly popular. It should be expected that in the next few years, a virtual assistant may become one of the common forms of interaction with the bank (e.g. via chat we will make a transfer) or devices (e.g. Siri).
5. Acquiring Millennials, customers from Z or C generation [36] should be one of the most important goals of every bank. It is estimated that Millennials themselves already account for 30% of all bank customers in Poland [37]. These modern consumers, who are so-called digital natives pose completely new and often unknown challenges to banks, and in the coming years their impact on the development of banks will be even greater. For a new consumer, having a deposit or using a loan are only steps to achieve the right goal, e.g. buying a flat. The dissonance between the expectations of these generations and representatives of "older generations" therefore forces banks to define a new approach. Banks are facing the need to change the strategy and apply an innovative approach in the area of product offer and communication. Those banks that meet the needs of new customers and adapt to their lifestyle will consequently gain loyalty of young customers. These banks will become the institution of first choice when making important financial decisions and will be gladly recommended to others. Banks should therefore take the role of a guide that guides new generations of customers through the world of finance and supports them in achieving their goals in the fastest and most convenient way possible [38].

1.9.2 Risk Management Principles in Electronic Banking and Related Challenges

The risk management mechanism is today the basis for solving problems on many levels. It is also an obligation pursuant to Article 8 and Article 17 of the Cyber Act. Systematic risk assessment and management should be the foundation of a safety management system.

Standards and legislation in many countries have been talking about risk management for decades. The most common standard for this subject is ISO 31000 or ISO/IEC 27,005 dedicated for information security [39, 40].

Risk management (risk management) is the making of decisions and implementation of activities leading to the entity achieving an acceptable level of risk. In practice, risk management is identified with risk diagnosis and control processes, the purpose of which is to intentionally ensure stable financial results and create conditions for further development.

Each risk assessment method has common elements. These include identification of threats, assessment of the likelihood of potential threats and losses that it can bring. This applies to both the business and social sphere. Regardless of which methods or strategy a company chooses, you should always collect information that will help identify and develop the optimal risk management methodology. Each of the process of risk management consists of four successive stages:

- risk identification,
- risk measurement,
- risk management,
- risk monitoring and control [41].

Banking organizations have been providing electronic services to consumers and businesses remotely for years. Electronic funds transfers, including low value payments and corporate cash management systems, as well as publicly available ATMs for withdrawing funds and managing retail accounts operate around the world. However, the growing acceptance of the Internet worldwide as a distribution channel for banking products and services provides banks with new business opportunities and benefits for customers in the field of services provided to them.

The EBG has determined that the basic features of electronic banking (and more generally electronic commercial activities) pose a number of challenges for risk management:

- The speed of changes in technological innovations and innovations regarding customer service in electronic banking is unheard of. Historically, new banking applications have been introduced over relatively long periods of time and after thorough testing. Currently, however, banks are experiencing competitive pressure to prepare new operational applications in a very limited time frame. Often, this period is several months, from concept to production. This competition increases

management's challenges in carrying out—prior to the introduction of new electronic banking applications—adequate strategic assessment, risk analysis and security reviews.

- For easier processing of electronic transactions, websites for entering into electronic banking transactions and related applications for retail and wholesale activities are usually integrated as much as possible with other computer systems. Such direct automated data processing reduces the potential for human error and fraud as an integral part of manual transactions. However, it increases dependence on the reliability of system design and architecture, as well as their ability to cooperate with other systems, as well as the operational capacity of the system.
- Electronic banking increases the dependence of banks on information technology, thereby increasing the technical complexity of many operational and security issues and reinforcing the trend towards more partner agreements, alliances and service contracts with third parties, many of which are not regulated. This development of events leads to the creation of new business models including banks and non-banking entities, such as companies providing internet services, telecommunications companies and other technology companies.
- The Internet is by its very nature ubiquitous and global. It is an open network accessible from anywhere in the world by unknown users. The Internet involves sending information through unknown locations and via fast-growing, cable-free tools. For this reason, it significantly increases the importance of security controls, techniques for confirming customer identity, data protection, procedures, audit trails, and customer data confidentiality standards [42, 43].

1.9.3 Twilio

Twilio is a programming platform for communication. Development teams use the Twilio APIs in the application to add features such as voice, video, and text messages. In this way, companies provide their customers with adequate communication. An extensive network, a software layer that connects and optimizes communication networks around the world is responsible for this. In this way, users can call and send messages anywhere. Thanks to Twilio, you can reach customers in the way they choose and effectively support cooperation. Improving cooperation has become a key factor for the success of companies, which is why this type of communication has a great impact on the development of the brand. Twilio is currently used in communication by more than 40,000 companies around the world [44].

Twilio is a solution in which it took over the global telecommunications network and transformed it into a cloud-based communication platform with the possibilities of:

- Voice—APIs and SDKs for building connection possibilities in web and mobile applications are responsible for this. They give the ability to connect to landline phones, mobile devices and even WebRTC clients. You can make calls from the application or operate international call centers.

- Video—Real-time video infrastructure and SDKs for embedding video collaboration and sharing contexts in a web or mobile application. A global infrastructure that supports signaling, registration and media forwarding.
- News—API and SDK for sending and receiving sms, mms and IP messages worldwide from a web and mobile application and using intelligent delivery functions to ensure message transfer.
- Certification—It is a two-factor authentication service to strengthen and even replace the traditional username and password for websites, SaaS products and mobile applications.
- Connectivity—Global operator connectivity services have become simple and widely available, without prior agreements. Offers local and toll free phone numbers around the world with SIP connectivity provided as APIs.
- Monitoring and support—The console allows you to record all details of Twilio account operations and applications. And also the help of experts if needed.

1.9.4 Purpose of the SMART BANKING Application

The purpose of the system is to computerize and streamline the bank's operations. The application is intended mainly for bank customers. The system is to enable transparent and convenient use of landline bank services via the platform and stationary services. The application is to provide customers with comfort of use and security. The application is intended to facilitate and improve the employees' work and relieve them of certain activities.

2 Main Part

2.1 Research Question

When undertaking the project, we took into account not only market conditions, consumer needs or problems of the modern economy, but also the challenges faced by programmers. As a result of the analysis of the banking industry, cyber security and strictly business issues, we have identified those issues that we believe may be a problem during the implementation of the planned application.

- The programming challenge will be obtaining data from external sources, e.g. data on the location of ATMs, customer personal data.
- The programming challenge will be the integration of external data with our system.
- The programming challenge will be the integration of external email services for the needs of our system.
- The programming challenge will be storing and processing confidential data

- The programming challenge will be maintaining the security of the internet connection with the bank and data transfer so that it is resistant to hacker attacks.
- The programming challenge will be to encrypt shared data.
- The programming challenge will be to ensure that the program works on different platforms.

3 Model Building

3.1 Definitions, Acronyms, Abbreviations

1. System—a set of elements (objects) that are connected with each other (relationships) and both these objects and relations between them have their own characteristics (attributes). Each system also has a defined purpose for which it is (or was) created and the environment in which it works. Whenever the word system is used in this document, it should be understood as an electronic library system (also known as an electronic library).
2. System administrator—a person authorized by the Library Director to report defects to the contractor and to collect the removal of a defect.
3. Architecture—defines the division of software into components and defines the functions of these components and the relationships between them. It contains a formal description of the system, including the working environment, rules establishing its construction and development in accordance with the requirements set out in the document.
4. Failure—a defect in the System that causes its operation not in accordance with the requirements of the Documentation, which causes a break in the System's operation or a break in its activated functionality. This break prevents the use of part or all of the System, or systems connected to it.
5. Error—a defect in the System meaning a limitation of its performance, functionality or security, but allowing for further use of the System or systems connected to it.
6. Documentation—all documentation, order specifications, technical documentation, user documentation - created for the System and describing the operation of the System.
7. Project Plan—a control document for project management. Defines the processes necessary to meet the assumptions of the Project. Describes individual business goals and needs, Project products, organization and management method.
8. Project—a set of activities aimed at the performance and implementation of the System in a manner consistent with the Documentation.
9. Product—the result of work at individual stages or phases of the Project, which is defined in the description of the Documentation.

10. Replacement Solution—emergency procedures, additional software or hardware provided by the contractor, designed to maintain the continuity of System operation until the Defect is removed.
11. Performance tests—a process that checks whether the System meets the performance requirements specified in the Documentation.

3.2 Product Range

The product is a banking system that customers and employees will use. The system is designed for internet browsers. The system can be operated using a computer and mobile devices such as a mobile phone. The application is written in C# technology. It was designed based on the Model-View-Controller pattern. The view includes all application windows that present the user with a graphical interface. The controller is responsible for forwarding user requests to the Model. The model is responsible for the business logic of the application and for access to the database.

In order to improve the operation of the application and increase security (double user verification), the program uses external e-mail and sms operators.

3.3 Assumptions

The system will provide the above functionalities with the given non-functional assumptions.

3.3.1 Functional Requirements

1. Logging in using the login and password.
2. Additional authentication with a code sent by sms to the phone number.
3. The third incorrect login blocks the user account.
4. Displaying personal data, account number and account balance.
5. Making transfers.
6. Viewing transaction history.
7. Order payment card, where ordering a new card requires deactivation of the old card.
8. Deactivation of a payment card.
9. Display of the nearest ATMs.
10. Sending email notifications.
11. Suggesting an address when entering, e.g. in the recipient's details.

3.3.2 Non-Functional Requirements

1. The system must be easy to use (short time for the user to learn how to use the system).
2. The system must ensure continuous availability 24 h a day, 7 days a week. A temporary interruption in the system operation is allowed while the application is running in safe mode.
3. The application is to be available in two language versions: Polish and English.
4. The system should work with all operating systems.
5. The system should be able to expand with new functionalities.
6. The system should respond quickly to user actions.
7. The system should be able to be repaired in a short time.
8. The system should prevent data loss.
9. The system should work with the most popular web browsers: Chrome, Safari, Mozilla Firefox, Opera, Internet Explorer, Microsoft Edge
10. The system must ensure that a daily payment transaction limit is imposed.

3.4 Use Case Diagram

The use case diagram is a diagram that shows the functionality of the system along with its surroundings. This diagram graphically shows the system properties as they are seen on the user's side. Our users are: client (main user), bank employee, interbank clearing system. Each of these users can perform certain actions. In the case of the customer, the starting point for performing the activities is logging into the system (with us, there is double user verification, the first is the login and password, the second is the code sent by sms). The client cannot take any action without it. Then the customer can choose what he wants to do next: see the history of operations, make a transfer, deactivate the card, order a new card, display ATMs. A bank employee can block a customer's account. The Interbank clearing system manages the transfer.

Many activities are related to each other by various dependencies (include and extend). For example, if a customer wants to make a transfer, they must first log into the system, then they must display the start page and select the option that they want to make a transfer, then enter the data for the transfer. Optionally, the system can suggest the recipient's address (if it is in the database). Only after all these activities the transfer is made.

Use case diagrams are used to illustrate services that are visible from outside the system. What is outside is outside the system (actors–client, bank employee, interbank clearing system), the rest (use cases) are placed inside. A use case is a set of scenarios linked to a common user goal. The use case is a graphical representation of the functional requirements. Among the cases of use of our system, we can mention, among others: displaying the history of operations, making a transfer, deactivating the card, ordering a new card, displaying ATMs (Fig. 2).

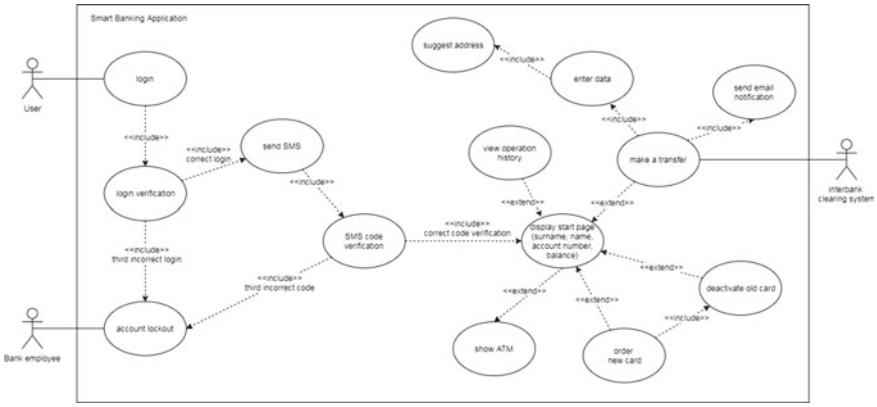

Fig. 2 Smart banking application use case diagram

3.5 Implementation Diagram

Implementation diagrams show the relationships between software (artifacts) and hardware (nodes). They are used when modeling large systems.

The implementation diagram reflects the physical structure of the entire system, including software and hardware. With us you can use the system on a desktop computer, laptop, tablet or mobile phone. These devices are represented in the form of symbols. Software units are represented by artifacts (that is, compiled versions of the component that can be run), data, and libraries.

Our system works in all web browsers (which has been included in the form of components). The system was built based on the MVC model (model, view, controller). This structure was also mapped through the components that build our application's server. Our system uses external artifacts, which has been shown in the diagram as a set of components: google maps, SMTP, POP3, IMAP and Twillo. A database server is an inseparable part of our system. As part of our database, we have three basic tables: customers, cards and transactions.

The hardware side is represented by nodes, i.e. individual computing, communication and storage devices, connected by communication paths (in our case they are HTTP/Internet connections, ODBC) (Fig. 3).

3.6 Class Diagram

The class diagram illustrates a certain set of classes, interfaces and cooperations, and the relationships between them. It is a graph consisting of vertices (classes, interfaces, cooperations) and arcs (represented by relations). The class diagram is a description of the system statics that highlights the relationships between classes, disregarding the

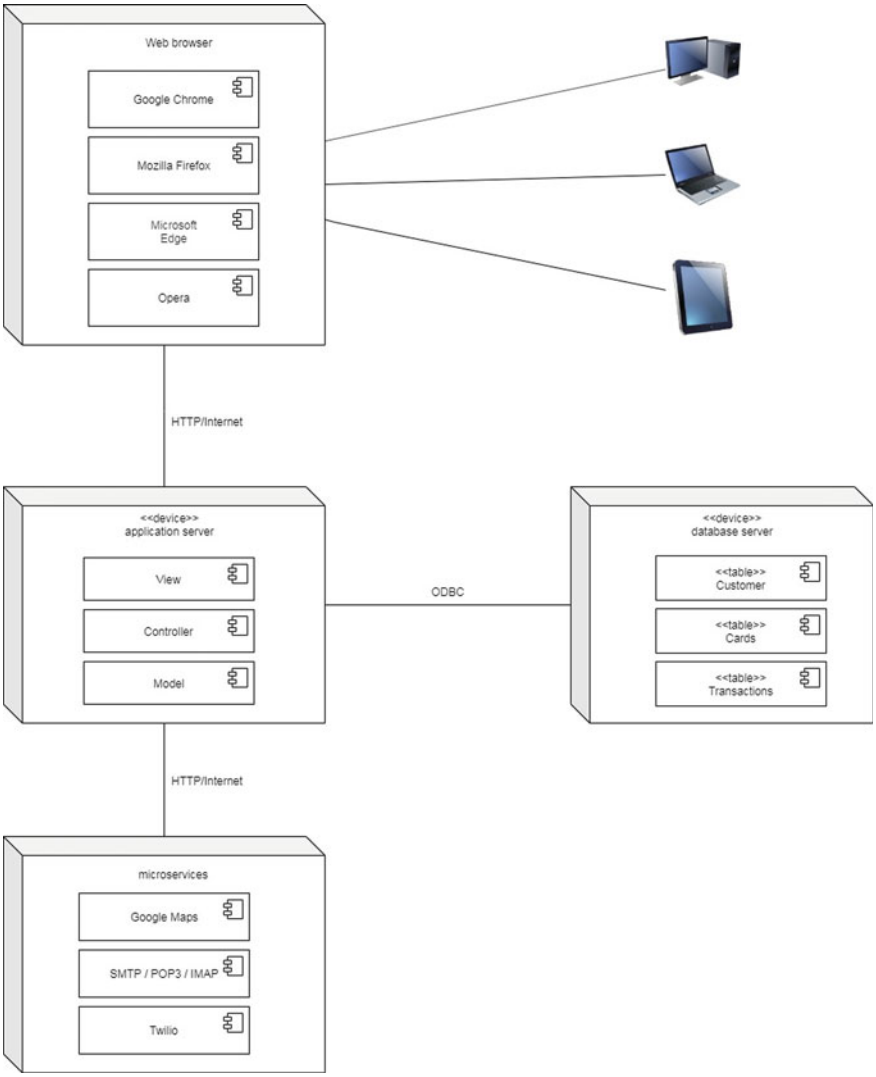

Fig. 3 Implementation diagram

other characteristics. Therefore, it most strongly presents the structure of the system, constituting the basis for its construction. We should remember that the assembly of all diagrams, or rather their elements and relationships, is a complete model. Class diagrams being the result of analytical decisions form the so-called views of the classes involved in the implementation of the use case (called. view of Participating class—VOPC) and the connections between them. The use case diagram is described in Sect. 4.4. Our class diagram takes into account the structure in which the project is created—MVC. We have classes here responsible for all three elements: Model,

View and Controller. In addition, we have classes that represent our elements in the database: cards and transactions. For this we have classes responsible for the view (they were divided into different views, depending on what function or use case will be performed by the user).

Basically, however, class diagrams are used to illustrate the static aspects of a design perspective, which takes into account the functional requirements of the system—the services that the system should provide to its users.

With this in mind, in the class diagram, in addition to the properties of individual classes, we also show the functions for which these classes are responsible. We also show the relationships between individual classes. For example, the controller class is responsible for displaying views and performing various actions to verify the customer and his data. To ful fill its functions, this class must download elements from the View and Model Customer classes. Accordingly, the View class is related to two other classes by dependencies. There are different types of relationships between classes:

From association bundles (associations). Example: the relationship between the CustomerDAO class and the ModelCustomer class (Fig. 4).

An association relationship is a semantic relationship (relationship) between two or more classes that establishes relationships (bindings) between instances of classifiers. In particular, association can occur between two or more classes. Often, role and number names are added to the link.

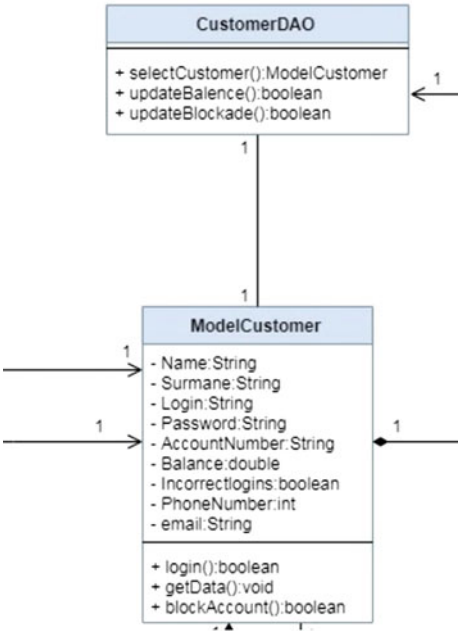

Fig. 4 The relationship between the CustomerDAO class and the ModelCustomer class

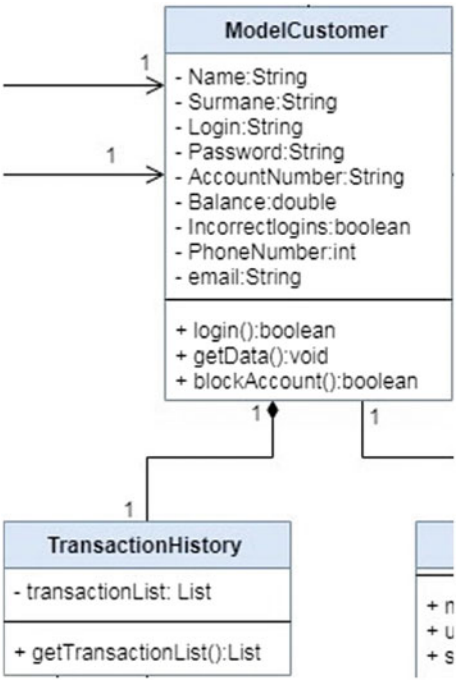

Fig. 5 The relationship between the ModelCustomer class and the TransactionHistory class

Strong aggregation (composition). Example: the relationship between the ModelCustomer class and the TransactionHistory class (Fig. 5).

The relationship of strong aggregation (composition, total aggregation) is a kind of aggregation with the belonging of the components to the parent and with the associated lifetime of the components with their parent. Components can be created after creating a parent. Once created, they exist and are deleted along with their parent. They can also be deleted before the parent element is deleted. The composition may be recursive.

Inheritance. Example: the relationship between the Transaction class and classes and TransactionDAO (Fig. 6).

Inheritance is the main pillar of the object oriented programming paradigm. Inheritance makes it possible to extract features common to several classes and enclose them in a more general class—with a higher level of abstraction.

Classes that inherit from the base class take on its features. This allows you to significantly shorten the code and organize the code from the logical side (Fig. 7).

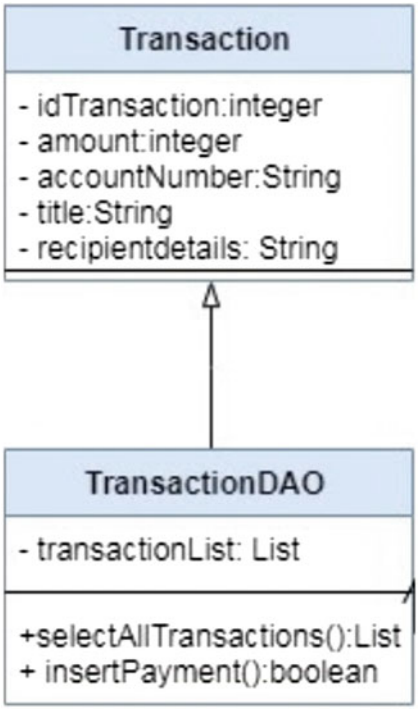

Fig. 6 The relationship between the Transaction class and classes and TransactionDAO

3.7 Component Diagram

The component diagram is used to illustrate the organization and relationships between components. The component diagram presents the system at a higher level of abstraction than the class diagram, since each component can be an implementation of one or more classes. The component diagrams are used to specify the details necessary for the system construction. project manager to present the complexity of the system and the possible division into implementation stages.

A component is a replaceable, executable part of the system, with hidden implementation details (e.g. Dll file, subroutine). The component provides a set of interfaces and may require some interfaces to function. A component is a replaceable, executable part of the system with encapsulated implementation details. Components are inherently reusable by connecting them to other components, usually by configuring them, without recompiling. The functionality offered by the component is available through the interfaces it implements. On the other hand, a component may require some interfaces that must be provided by other components.

The component diagram is used to show the relationships between components and interfaces.

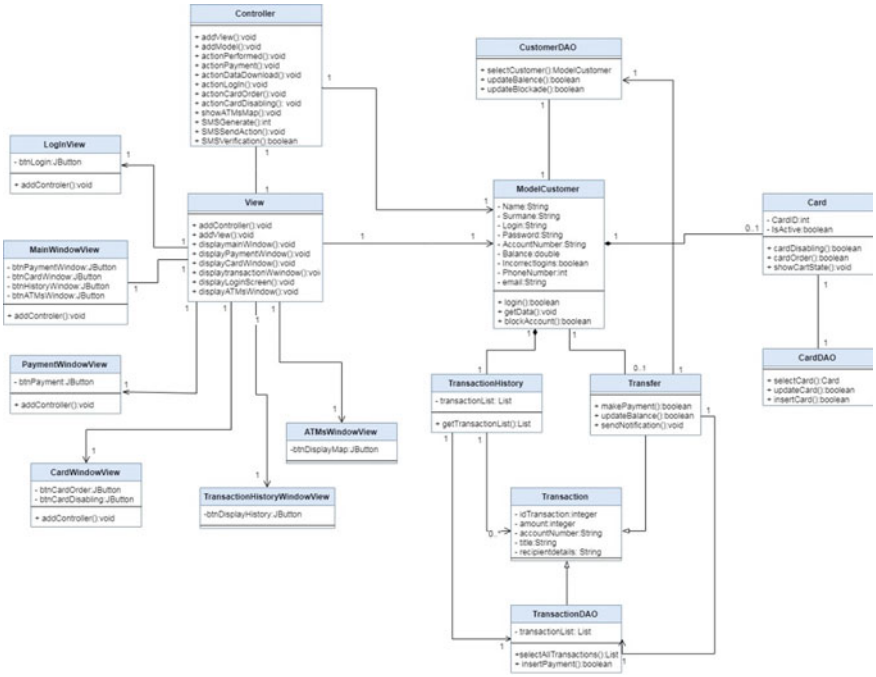

Fig. 7 Class diagram

The components are interrelated because they require them to implement their own functionality. The relationship between A and B means that component A uses component B and a change in component B may necessitate a change in A.

For example: In our program, the controller is responsible for starting the action of sending sms to the customer. The controller, however, commissions this task to an external unit, which is Twillo here.

The customer wants to see the transaction history. The TransactionHistory class is responsible for running the function responsible for showing transaction history. However, in order to be able to provide information about transactions, this class must use the Transaction Base component.

If the customer wants to see the user panel, several components are also responsible for showing it. The Controller class is responsible for running the function responsible for just showing the Interface. However, this class, to be able to show the above the panel must use the User Interface component which is responsible for the view (Fig. 8).

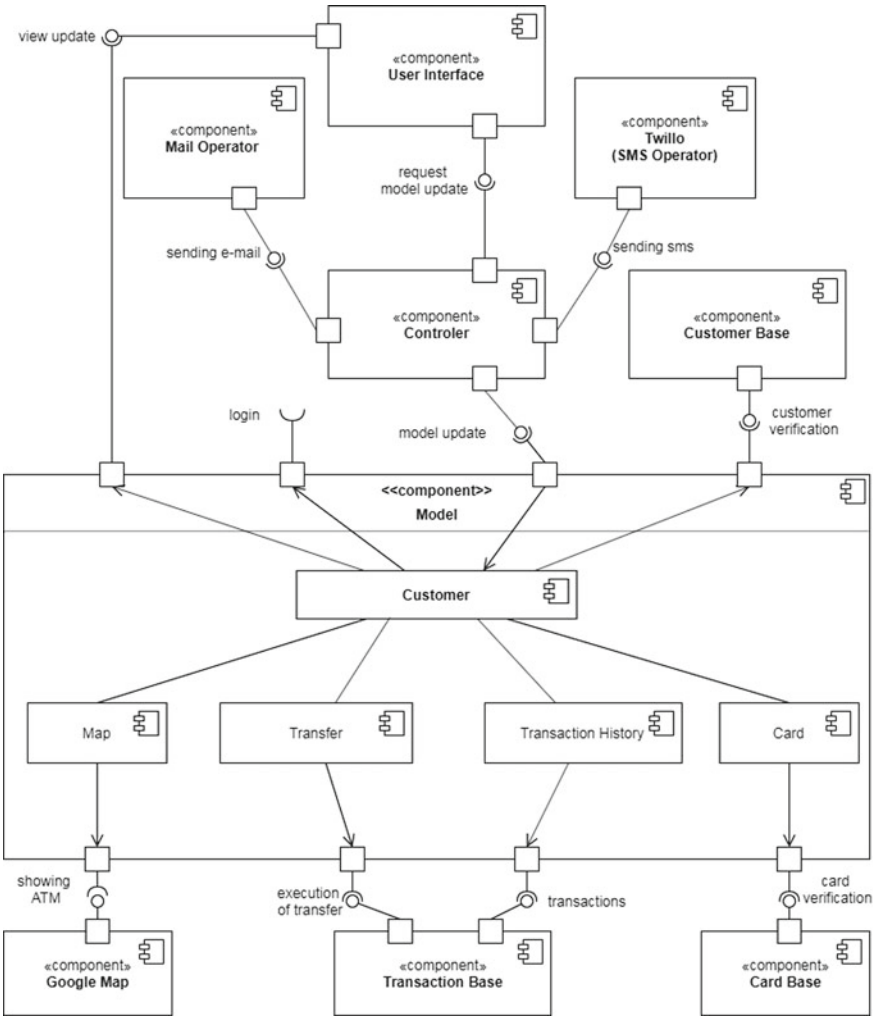

Fig. 8 Component diagram

3.8 Communication Diagrams

The communication diagram is one of the interaction diagrams. The communication diagram shows how to exchange messages between objects participating in the interaction.

The communication diagram focuses on the objects interacting and the messages they exchange, while to a lesser extent than the sequence diagram (although still present) it indicates the temporal aspect. For this reason, the objects in the communication diagram are positioned so that it is easy to describe their relationships with each

other. Communications are represented by lines connecting objects, while messages and data sent between objects are placed next to these lines. Each message has a numerical label indicating the order in which they were sent. This label is in the form of numbers separated by periods. In the case of control separation, each step adds the next successive fields with numbers to the step labels, e.g. step 2 creates steps 2.1, 2.2 immediately following it. Step 2.1 has steps 2.1.1 and 2.1.2, etc. Unlike sequence diagrams, communication diagrams cannot convey much information about interactions, e.g. message blocks. On the other hand, however, they present the real relationships between objects and their relationships, which can help you understand the interaction.

3.8.1 Communication Diagram—User Verification—Client/System Login

The client is the main actor in this diagram. The client communicates with the rest of the system via the GUI. Further communication takes place via a controller. It is the controller that decides what action is taken next (of course, the customer first chooses what he wants to do):

- If the customer wants to log into the system, the controller communicates with ModelCustomer, which retrieves data from the database (JDBC). Further ModelCustomer verifies the correctness of the data and informs the Controller. The controller through the GUI communicates with the user and provides him with information about the correct login.
- If we want to download an SMS, the controller communicates with the external Twillo platform, which then communicates with the user's phone and sends an sms.
- If the client sends an sms, the controller is responsible for verifying the sms and sends the information to the user's panel (Fig. 9).

3.8.2 Communication Diagram—Making a Transfer

The client is the main actor in this diagram. The client communicates with the rest of the system via the GUI. Further communication takes place via a contrtoller. It is the controller that decides what action is taken next (of course, the customer first chooses what he wants to do):

If the customer wants to make a transfer, he informs the system by pressing the button. When the controller receives information from the client (via the GUI) that he has pressed on button, the conttoller communicates with the ModelController. ModelController thus receives orders from the Controller that it must order Spilway to check the correctness of the data in the Database (JDBC). Spilway informs ModelCustomer about the correctness of the transmission. ModelController forwards this information to the Controller. next the Controller undertakes an action to send an email. Send an email to MailOperator. MailOperator sends an email and informs the

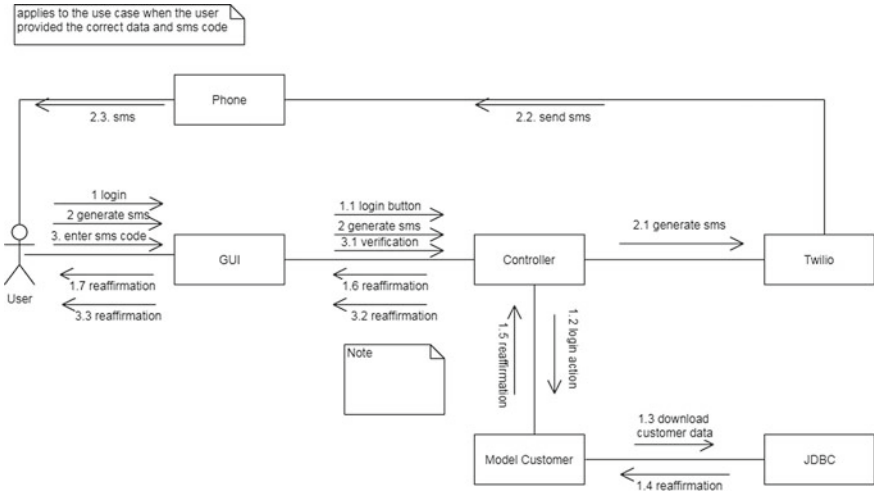

Fig. 9 Communication diagram—user verification

Controller about it. The controller provides the client with confirmation via the GUI (Fig. 10).

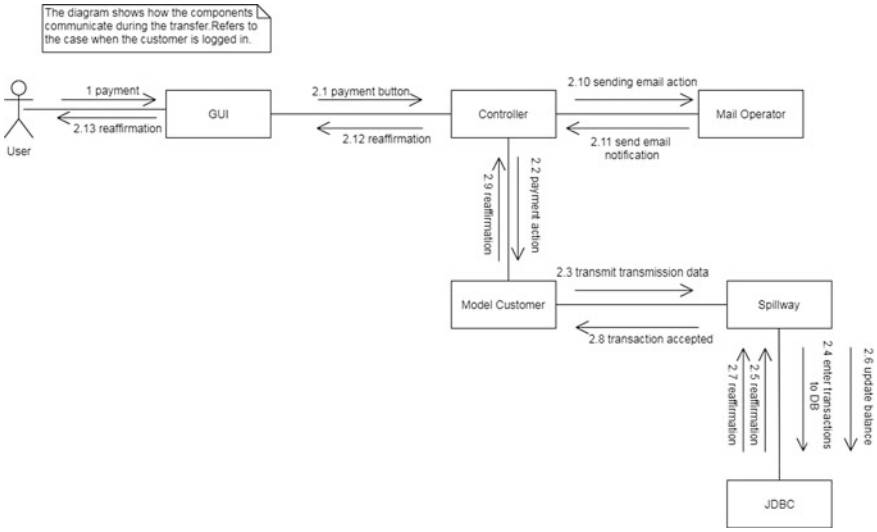

Fig. 10 Communication diagram—making a transfer

3.8.3 Communication Diagram—Displaying Transaction History

The client is the main actor in this diagram. The client communicates with the rest of the system via the GUI. Further communication takes place via a controller. It is the controller that decides which action to take next:

In this case, the customer chooses the option that he wants to see the transaction history. This information is transferred to the system by pressing the appropriate button on the GUI. The controller communicates with Model Customer to download information from the database (JDBC). ModelCustomer forwards information to the controller. The controller displays information to the user via the GUI (Fig. 11).

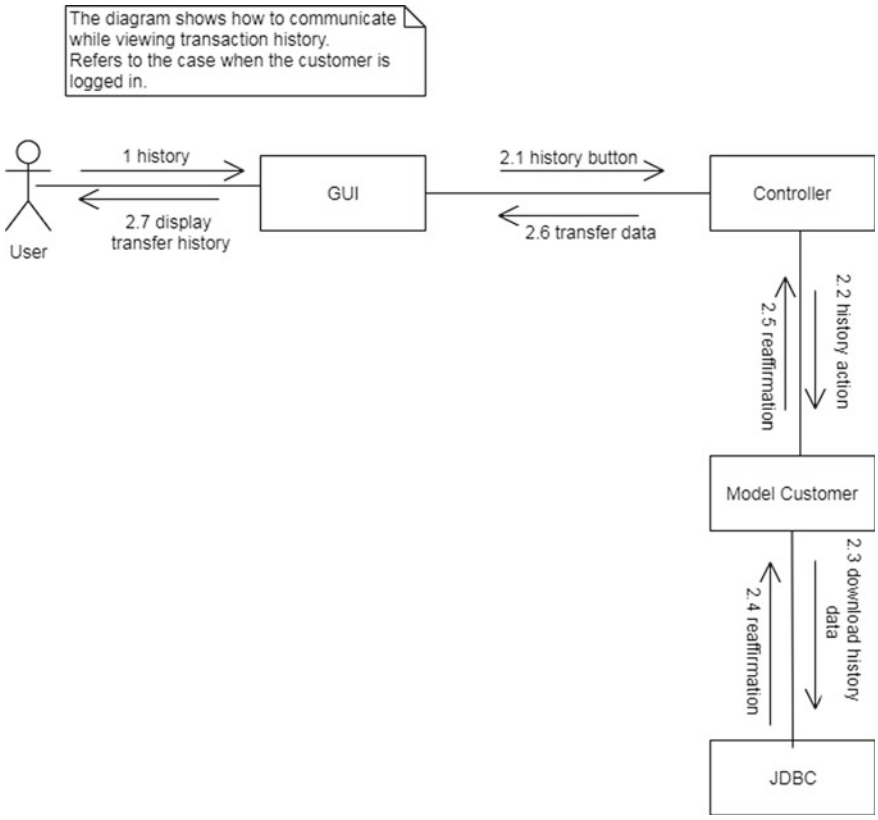

Fig. 11 Communication diagram—displaying transaction history

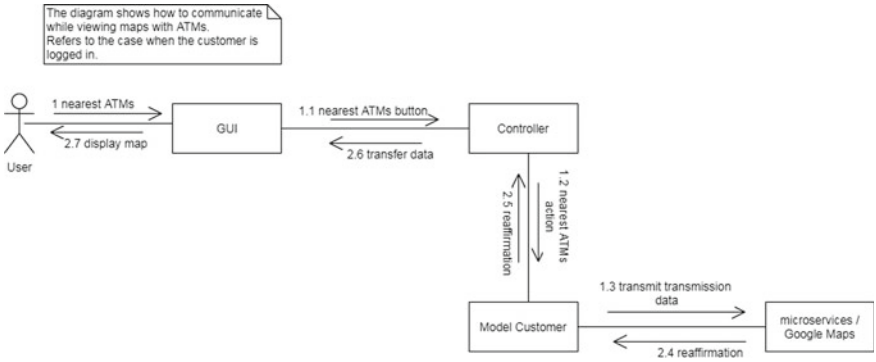

Fig. 12 Communication diagram—displaying the map of the nearest ATMs

3.8.4 Communication Diagram—Displaying the Map of the Nearest ATMs

The client is the main actor in this diagram. The client communicates with the rest of the system via the GUI. Further communication takes place via a controller. It is the controller that decides which action to take next:

In this case, the customer chooses the option that he wants to see the nearest ATMs. This information is transferred to the system by pressing the appropriate button on the GUI. The controller communicates with Model Customer to download relevant information from GoogleMaps. ModelCustomer forwards information to the controller. The controller displays information to the user via the GUI (Fig. 12).

3.8.5 Communication Diagram—Ordering a New Payment Card

The client is the main actor in this diagram. The client communicates with the rest of the system via the GUI. Further communication takes place via the controller. It is the controller that decides which action to take next:

In this case, the customer chooses the option that he wants to order a new card. This information is transferred to the system by pressing the appropriate button on the GUI. The controller communicates with Model Customer so that the one in the Database (JDBC) deactivates the old customer card. After deactivating the old card, ModelCustomer forwards to JDBC to order a new card. Next ModelClient transmits the order confirmation order to the Controller. The controller through the GUI transfers information about the order to the customer (Fig. 13).

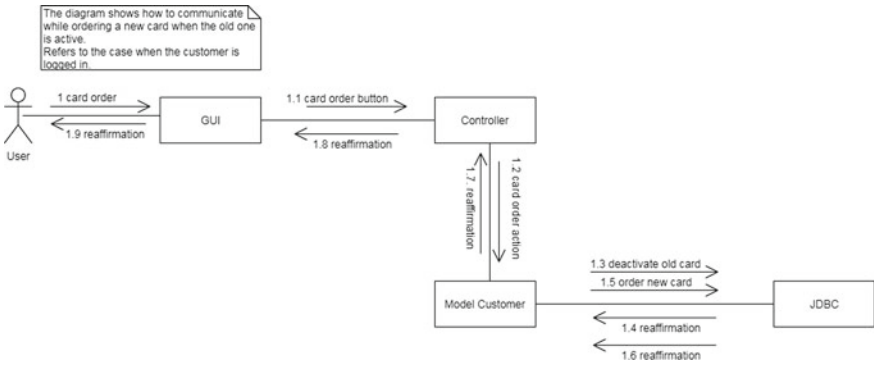

Fig. 13 Communication diagram—ordering a new payment card

3.9 Sequence Diagrams

Sequence diagram (called. Sequence diagram) is used to present the interaction between objects including consideration at the time of the messages to be transmitted between them. In the sequence diagram, objects are arranged along the X axis, and messages are sent along the Y axis. The principal use of sequence diagrams is modeling system behavior in the context of use case scenarios. Sequence diagrams help answer the question of how communication between objects progresses over time. In addition, sequence diagrams are the basic technique for modeling system behavior that makes up the use case.

3.9.1 Sequence Diagram—User Verification—Client/System Login

Here the main actor is the client. The following class objects also take part in the sequence: Controller, LoginController, ModelCustomer. GUI is used to communicate with the system. The entire sequence also includes external components: an email sending platform—Twillo and a Database with customer information.

The main actor is the client, but at the same time he is an object in the system because he appears as an entity in the database. It can be said that the user—client representation is the object in the system—entity in the Database.

To start with, the client through the GUI (by selecting the appropriate button) calls the procedure aimed at run login action. The controller instructs the ModelCustomer object to perform user verification. The ModelCustomer object retrieves data from the Database to perform verification. The ModelCustomer object then performs the verification.

(a) login/password correct:

- If the verification was successful, the call returns from the call—confirmation of the correctness of the data and granting access to the client.

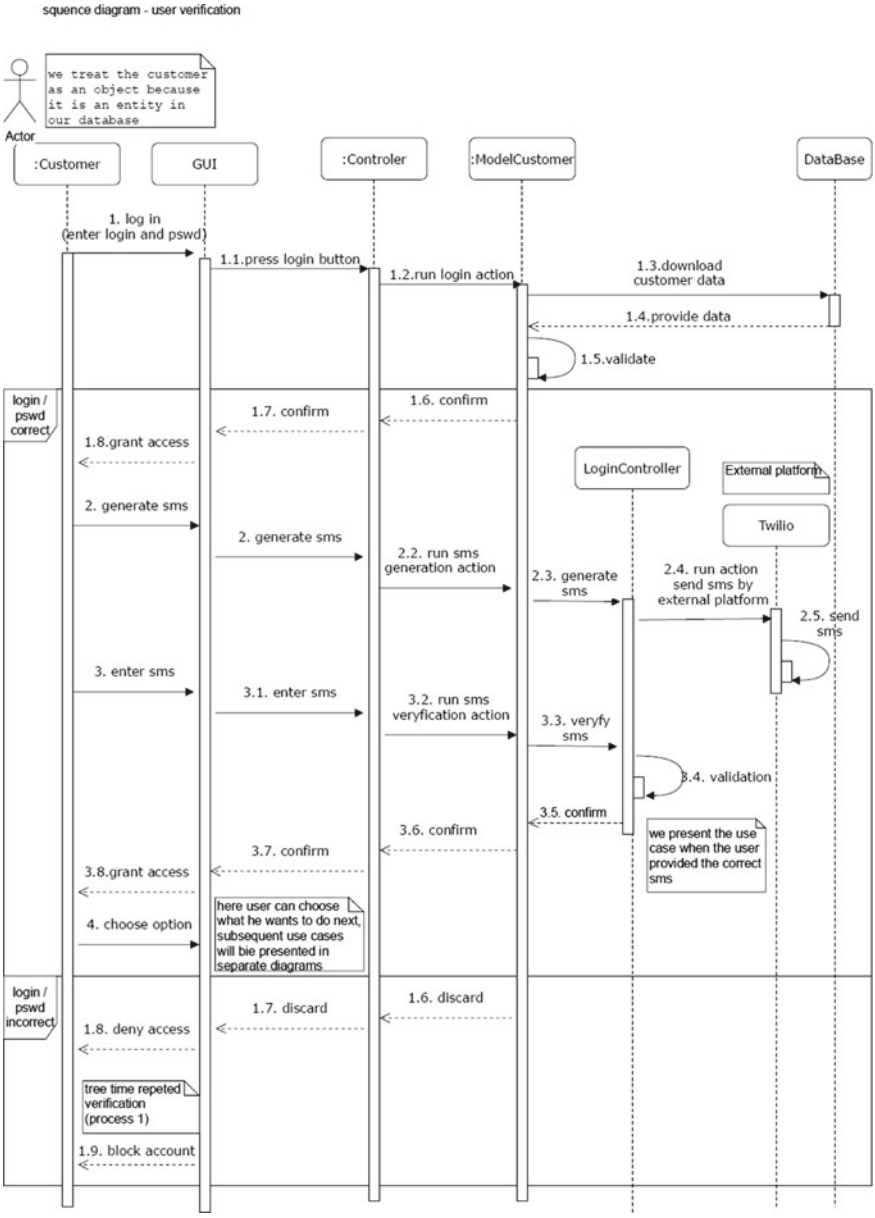

Fig. 14 Sequence diagram—user verification

- Then the client through the GUI (by selecting the appropriate button) calls the procedure generating the sms. The controller instructs the ModelCustomer object to call a procedure to generate a sma
- An SMS is generated by LoginController and sent by the Twillo Platform.
- Next, when the customer already has an SMS, enter it into the system (via GUI)
- Thus, an action is called to verify the text. Activity is outsourced to LoginController (via the Controller respectively and ModelClient)
- After verification, the call returns and the confirmation is forwarded to the GUI.
- Through the GUI, the customer gets information about access to the system.

Description of the scenario for the sequence diagram:
user verification—client/logging into the system:

- The use case starts when the client enters parameters such as login and password in the system (via GUI).
- The customer presses the login button to gain access.
- The client login action is launched.
- Customer data is retrieved from the database.
- The correctness of the data is being verified.
- If the data is correct:
  - Information confirming the correctness of the data is transferred to the system
  - The customer receives an SMS that must be entered into the system to gain access to the account
  - The customer gains access to his account.
- If the login details (user name, password) are incorrect:
  - Information confirming that the data is incorrect is transferred to the system.
  - The customer receives information about data inconsistencies
  - The customer repeats the attempt to log into the system three times.
  - After the third attempt, in the event of a discrepancy information, the customer's account will be blocked.

3.9.2 Sequence Diagram—Making a Transfer, Cases

In this case, the main actor is also the client. The sequence includes the objects of the following classes: Controler and ModelCustomer and the components: Data Base and Email Operator. GUI is used to communicate with the system. As in the previous case, the client is not only an actor, but also an object—an entity in the database.

The diagram shows the actions of making a transfer if the customer is already logged in to the application. Three scenarios described below the diagrams are presented:

(a) sequence diagram—making a payment when the entered payee's account number is incorrect.
(b) Sequence diagram—making a payment when all entered data is correct.
(c) Sequence diagram—making a payment when the account number has been entered correctly, but the amount is greater that the account balance from which we want to make the payment (Figs. 15, 16, 17).

Description of the scenario for the sequence diagram:
attempt to make a transfer:

- The use case begins when the customer selects the appropriate button in the system (via GUI) (make a transfer)
- The customer then sees a window in which he must enter the account number in the first position
- An action is launched to verify the account number is correct
- If the data is correct:
  - Customer provides other information (transfer title, recipient's name, amount)
  - The system retrieves customer data—the amount of funds on the account
  - It is verified whether the amount of the transfer is less than the amount of money in the account
  - Information confirming the correctness of the data is transferred to the system
  - The customer receives a confirmation email, the transfer can be made.
- If the account number is incorrect, the transfer amount is correct:
  - Information confirming the incorrect account number is transferred to the system.
  - The customer receives information about an incorrect number
  - The customer re-enters the (corrected) number (we assume that he entered the correct number the second time)
  - Customer provides other information (transfer title, recipient's name, amount)
  - The system retrieves customer data—the amount of funds on the account
  - It is verified whether the amount of the transfer is less than the amount of money in the account
  - Information confirming the correctness of the data is transferred to the system
  - The system retrieves customer data—the amount of funds on the account
  - It is verified whether the amount of the transfer is less than the amount of money in the account
  - Information confirming the correctness of the data is transferred to the system
  - The customer receives a confirmation email, the transfer can be made
- If the account number is correct, the transfer amount greater than the sum of funds on the account:
  - Information stating the data error is transferred to the system.
  - Customer provides other information (transfer title, recipient's name, amount)
  - The system retrieves customer data—the amount of funds on the account

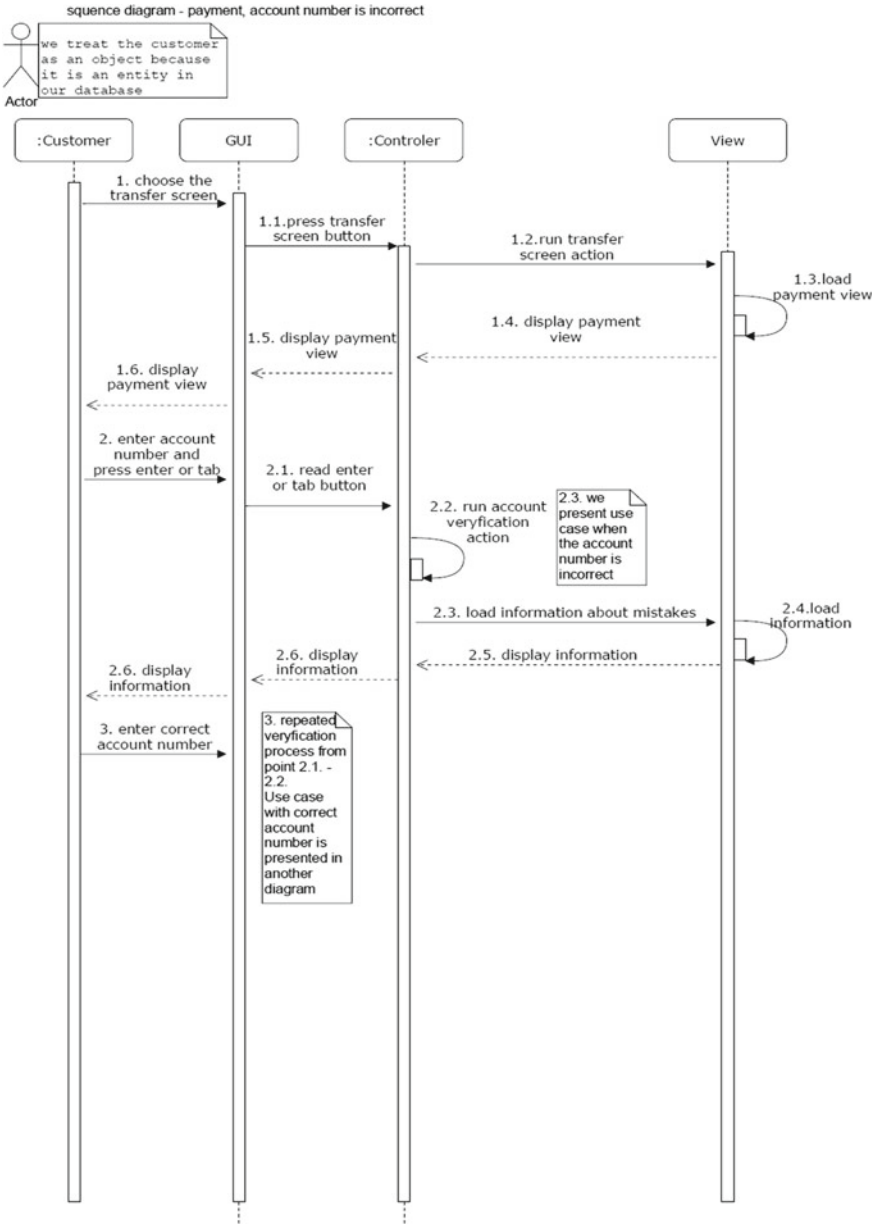

Fig. 15 Sequence diagram—making a payment when the entered payee's account number is incorrect

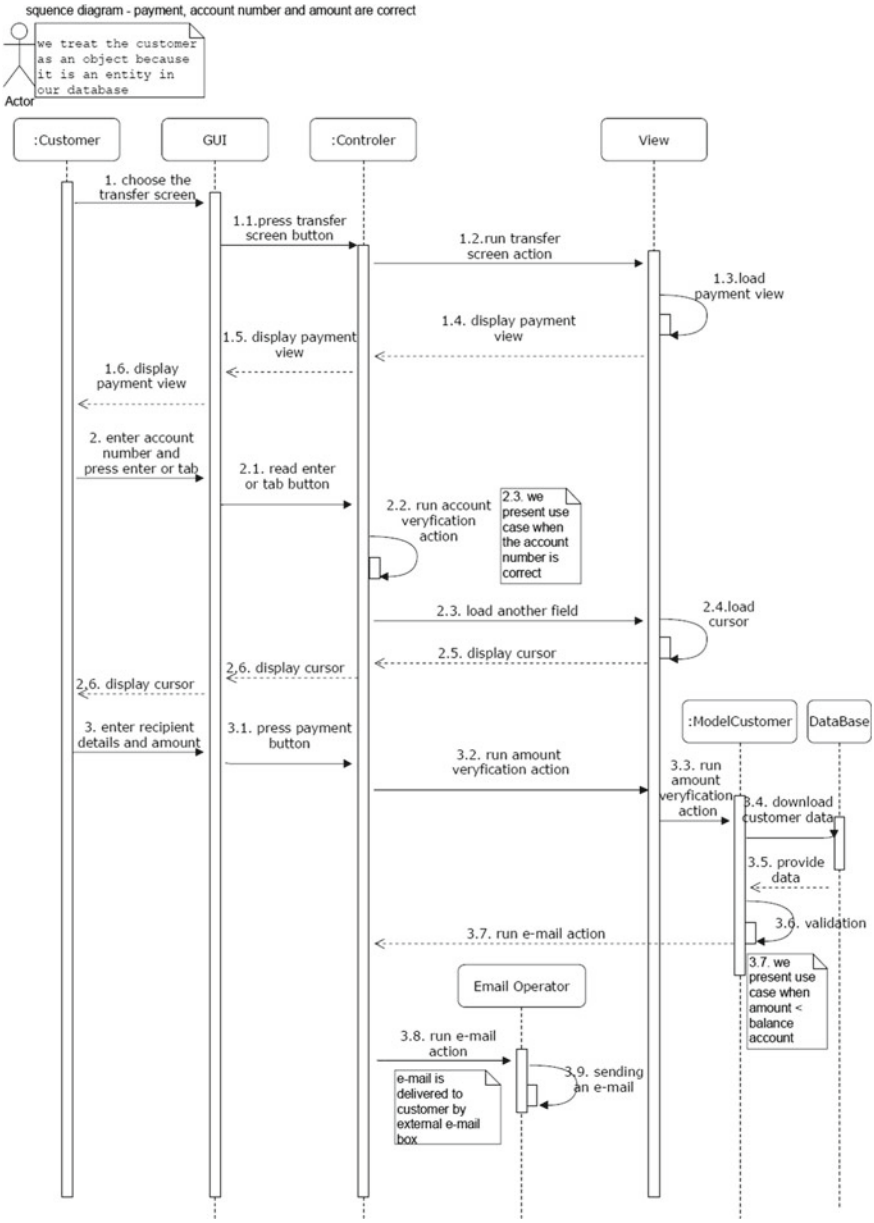

Fig. 16 Sequence diagram—making a payment when all entered data is correct

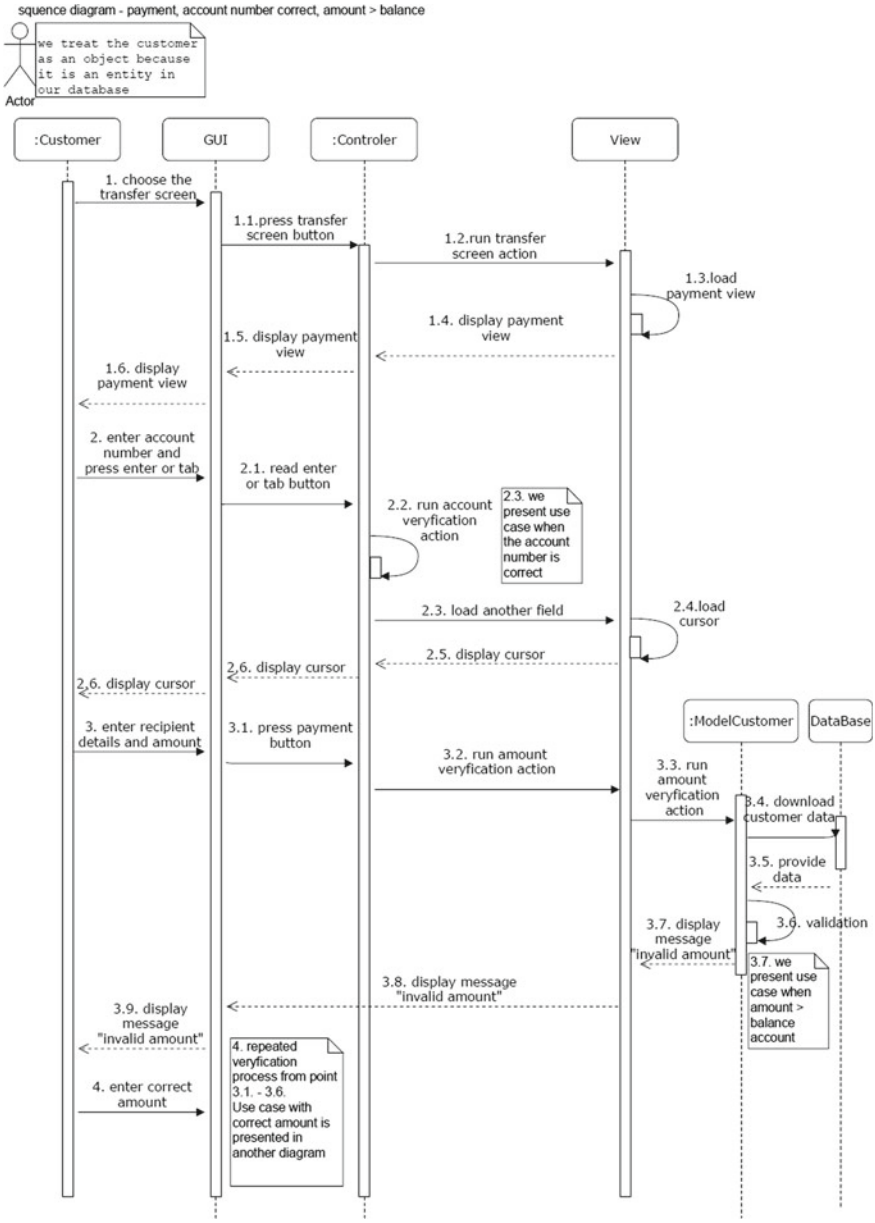

Fig. 17 Sequence diagram—making a payment when the account number has been entered correctly and the amount is greater that the account balance

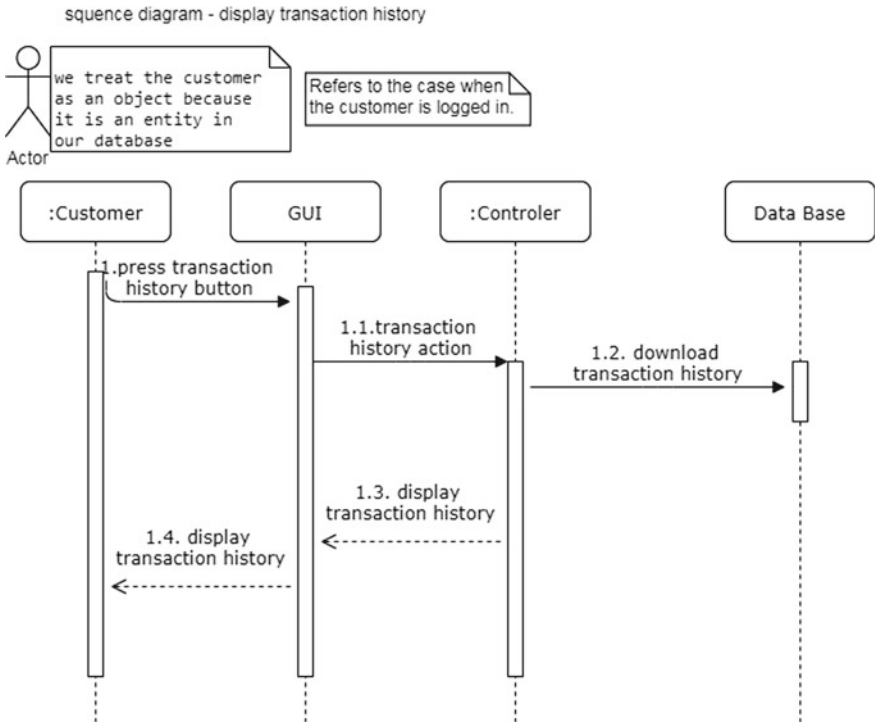

Fig. 18 Sequence diagram—displaying transaction history

- It is verified whether the amount of the transfer is less than the amount of money in the account
- The customer receives information about an incorrect amount
- The customer re-enters the (corrected) amount (we assume that he entered the correct amount the second time)
- The system retrieves customer data—the amount of funds on the account
- It is verified whether the amount of the transfer is less than the amount of money in the account
- Information confirming the correctness of the data is transferred to the system
- The customer receives a confirmation email, the transfer can be made

3.9.3 Sequence Diagram—Displaying Transaction History

The actor of the use case of the presented sequence diagram is the client, who is also an object and entity in the database. In addition to the client, the controller is the objects involved in the sequence diagram. The external Data Base component was used to retrieve the transaction history that is stored in the database. The actor

uses GUI to communicate with the system. The sequence diagram shows how the transaction history is displayed when the customer is already logged into the system.

Description of the scenario for the sequence diagram:

view transaction history:

- The diagram starts when the user is already logged in, sees the home page and selects the transaction history button,
- the history display action starts,
- data are downloaded from the database from the transaction history table,
- data is transferred to the user interface and displayed on the screen.

3.9.4 Sequence Diagram—Display the Map of Nearest ATMs

The actor is the client. The customer is also an object involved in the sequence and as in previous database entities. In addition to this object, the Controller class object is involved. The external component used in this case is the client with the system communicating via a graphical user interface. The diagram shows the use case when the client is already logged in to the system (Fig. 19).

Description of the scenario for the sequence diagram:

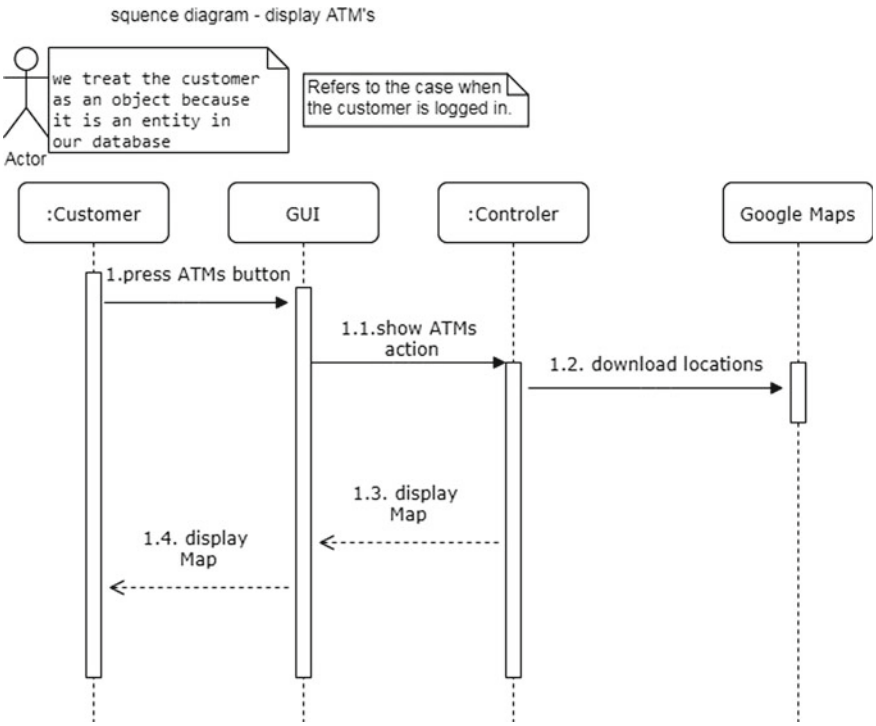

Fig. 19 Sequence diagram—display the map of nearest ATMs

displaying map with the location of the nearest ATMs:

- The diagram starts when the user is already logged in, sees the home page and chooses to display the nearest ATMs,
- the map display action starts,
- our location and ATM location data are downloaded from an external site—Google Maps,
- data is transferred to the user interface and a map with locations marked is displayed.

3.9.5 Activity Diagrams

An activity diagram is an interaction diagram that is used to model dynamic aspects of the system. Its main function is to present the sequence of steps that are performed by the modeled system fragment. The control flow modeled using the activity diagram consists of many events.

Events (executable, indivisible calculations) are stock states.

Actions are very similar to actions. The difference is that action states can be decomposed. An action can additionally have input and output actions.

Activity diagrams in which activities or actions are ordered sequentially are rare. The specification of the process using this diagram means the need to consider many alternative flows, depending on the fulfillment of conditions or the implementation of iteration. These situations can be defined using decision blocks that have the character of decisions or joins.

3.9.6 Activity Diagram—User Verification—Client/System Login

The first step is to enter your login and password. The system verifies the data. Action is taken in the decision block: if the data is not valid we go to the next decision block, which checks the number of login attempts, if it is less than 3 we return to step one and enter the login data again. If the data is entered incorrectly 3 times, the decision block will move to the account blocking action and the diagram will end.

When the login details are entered correctly, we proceed to the next step, we receive an SMS sent with the verification code. In the next step, enter the code. The decision block performs validation and, as before, if an incorrect code has been entered, we go to the next decision block. If the incorrect code has been entered less than 3 times, enter it again, if 3 times we go to the action that blocks the account and the diagram ends.

If the code has been entered correctly, the login is successful and the main window page is displayed. From there, you can perform further actions, which will be presented in the diagrams below (Fig. 20).

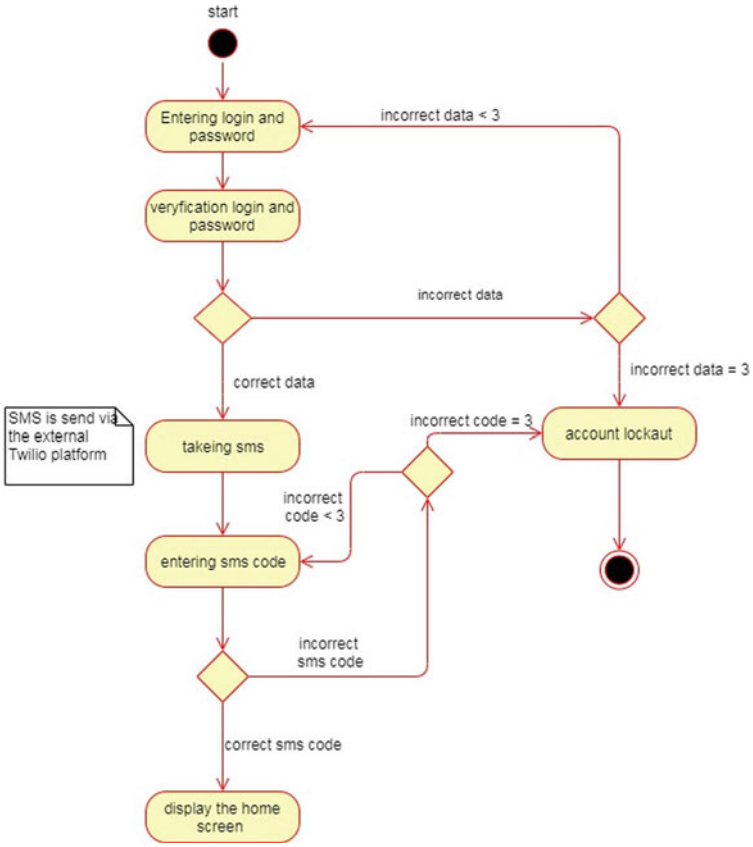

Fig. 20 Activity diagram—user verification

3.9.7 Activity Diagram—Making a Transfer

The diagram of the transfer operation is shown when the user has correctly performed the system login action. The home screen screen is displayed. The next step is to display the transfer execution screen. Enter the transfer recipient's account number. The number is checked in the decision block. if it is incorrect, repeat the action. When the account number is correct, we proceed to entering the recipient's data. The address entered is suggested. The next step is entering the transfer amount. The amount is compared to your account balance. If it is greater than the balance in the decision block it goes back to the previous step and you need to change the amount. When the amount is less than the account balance, we proceed to the next steps. In the concurrent flow, the account balance is updated and an SMS is sent with confirmation of the transaction. a merge activity diagram and August ends (Fig. 21).

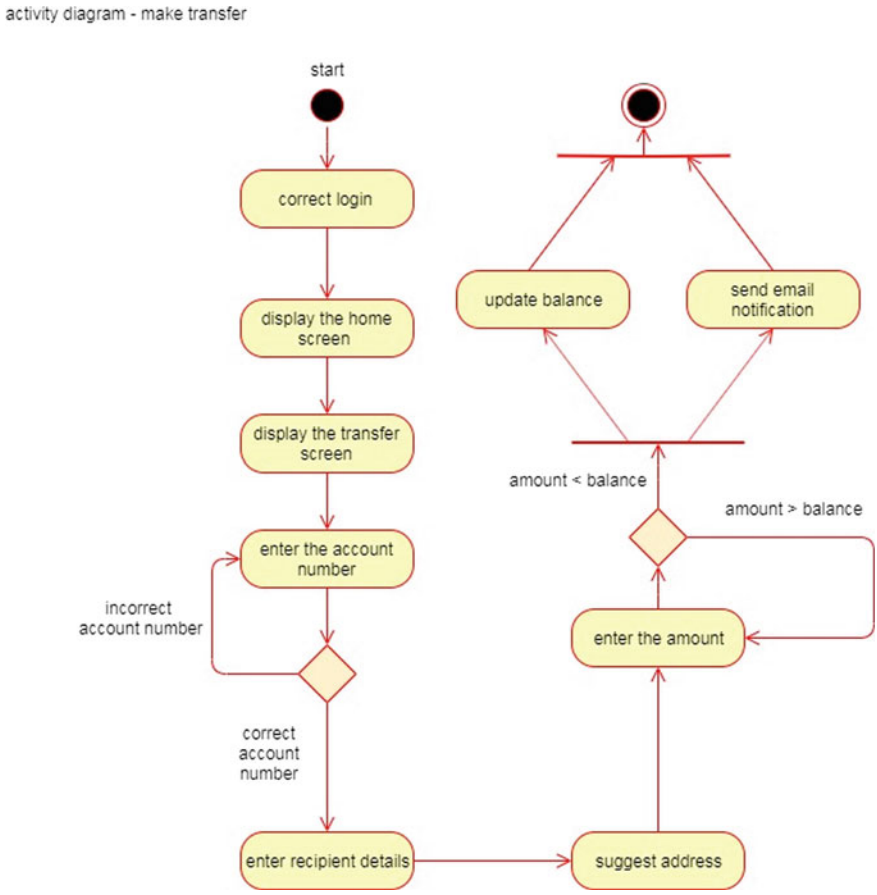

Fig. 21 Activity diagram—making a transfer

3.9.8 Activity Diagram—Displaying Transaction History

The transaction history display activity diagram is a very, short diagram, where the activities follow one another sequentially. After successful login the main page is displayed. Next, transaction history is displayed and the diagram ends (Fig. 22).

3.9.9 Activity Diagram—Display the Nearest ATMs

After the user logs in correctly, the application start page is displayed in the system. The next step displays a map with the nearest ATMs. The activity diagram ends (Fig. 23).

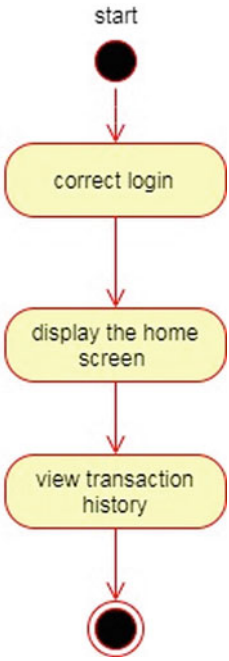

Fig. 22 Activity diagram—displaying transaction history

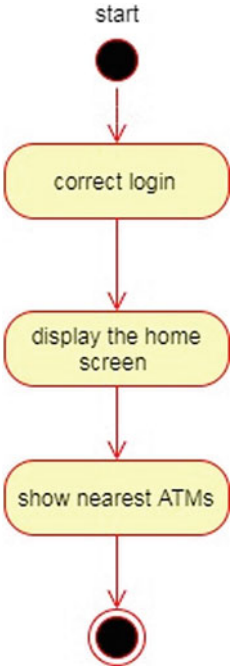

Fig. 23 Activity diagram—display the nearest ATMs

Fig. 24 Activity diagram—ordering a new payment card

3.9.10 Activity Diagram—Ordering a New Payment Card

After the user logs in correctly in the system, the application start screen is displayed. To order a new payment card, click the appropriate window and go to the new action. Then in the decision window it is checked if we have an active card. If so, we proceed to deactivating the old card. If we do not have an active card, a new card is ordered. The activity diagram ends (Fig. 24).

3.9.11 State Machine Diagrams

State diagram—a diagram used for analyzing and designing software. First of all, it shows the possible states of the object and the transitions that change this state. You can also read from it what sequences of input signals (data) cause the system to go into a given state, as well as what actions are taken in response to the appearance of certain input states. Thus, the life cycle of the object is created, which can be all the more important in the process of software development, the more possible states of the object.

3.9.12 State Machine Diagram—Making the Transfer

The diagram starts when we want to make a transfer and it has a "ready to make" status. After verifying the data, if the amount is greater than the account balance or the account number is incorrect, the transfer will change to "rejected transfer". After the data change, the transfer goes to the "ready to execute" state. If the entered data is correct, it goes into the "transfer accepted" state (Fig. 25).

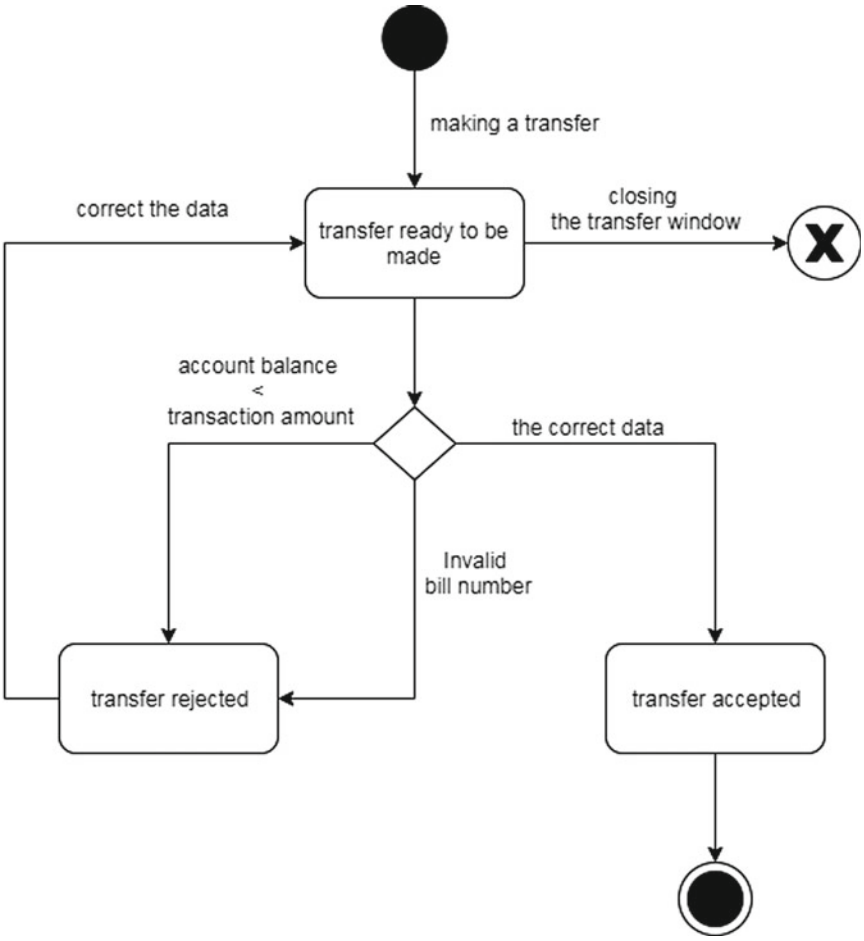

Fig. 25 State machine diagram—making the transfer

3.9.13 State Machine Diagram—Payment Card Order

If we want to order a payment card, it is checked at the beginning whether we have a card. If we do not have the status "inactive card". If the customer has a card, it has the status "active card". To order a new card, deactivate the old hangman. The previously active card changes its status to "inactive card". When the card is ordered, it has the status "card ordered" (Fig. 26).

4 Model Testing

4.1 Purpose of the Document

The documentation of the user of the IT system of the Banking Application is intended for people who want to use the bank's services anywhere, without the need to visit

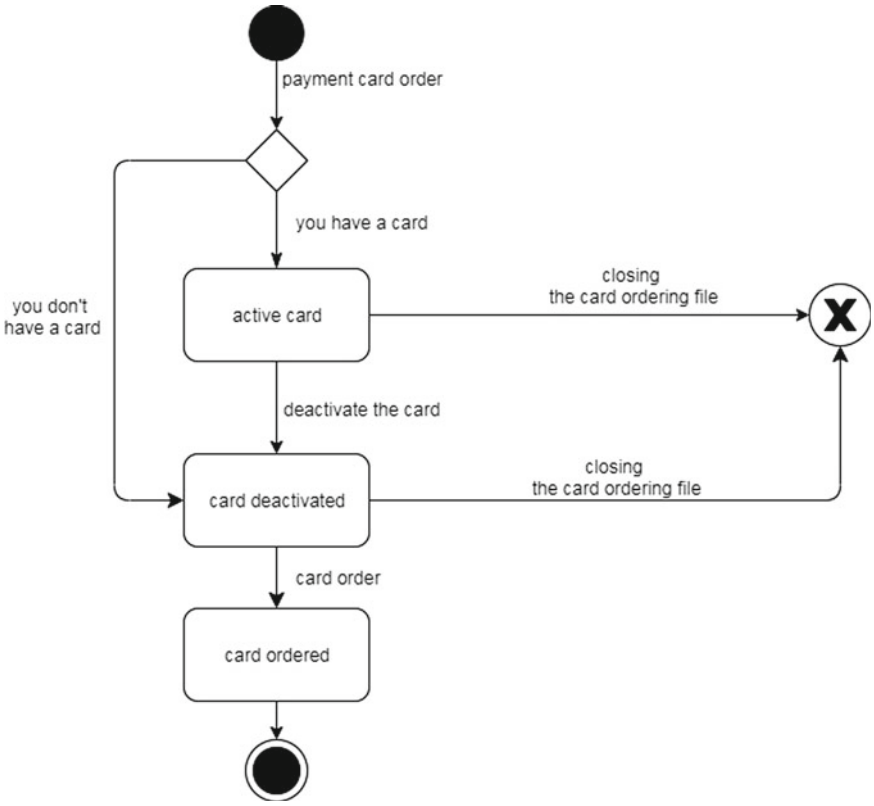

Fig. 26 State machine diagram—payment card order

a stationary branch. Here are screenshots showing how to proceed when we want to perform a specific action.

4.2 Admission

The system allows the user to log in using the password and login received by e-mail. In addition, the system has additional authorization via sms code.

The third incorrect login causes the user account to be blocked (The principle is the same at every stage of verification. You can enter the wrong password three times and you can enter the wrong PIN three times. The second stage of verification << SMS verification >> only starts after the first verification has been successfully completed << login and password verification >>).

The system displays the user's first and last name, his account number and current account balance.

The application allows you to make transfers. The transfer is confirmed by sending a notification to the e-mail address.

The system allows displaying the operation history.

It is possible to order a new payment card and deactivate the old one.

The system also has options for displaying the nearest ATMs on the map.

4.3 Access

The mobile application can be downloaded from the bank's official website: www.bank.pl/aplikacjamobilna. It is free and available to all bank customers.

4.4 User Documentation

4.4.1 Log in

After starting the application, a welcome page is displayed that allows you to log into the system. The user types in the appropriate ID and password, which he received by mail from the bank (Fig. 27).

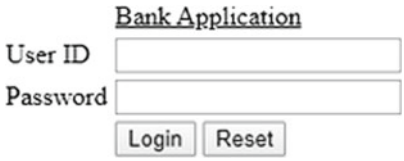

Fig. 27 Log in

Fig. 28 Log in—providing incorrect data

Fig. 29 Log in—entering password incorrectly 3 times

In case of providing incorrect data, the user will be informed by the system. Should then correct the entered data (Fig. 28).

If the user enters the password incorrectly 3 times, the account will be blocked and the user will be notified.

4.4.2 SMS Authorization

If you typed in the previous step, the data is correct, the user phone number on your phone receives an SMS with a code (Fig. 30).

This code should be entered in the field that appears (Fig. 31).

If the code is entered incorrectly three times, the account will be blocked and the user will be notified (Fig. 32).

4.4.3 Home Page

After logging in, the main page of the application is displayed, on which we see the first and last name of the logged in user, number and account balance. On the left side there are 4 tabs that can be used within the application. By clicking the logout button, you log out of the account and return to the login screen (Fig. 33).

4.4.4 Make a Transfer

After going to the tab responsible for making the transfer, a window like the one below will appear. Enter the recipient's account number and the amount of the transfer. In addition, we can enter the transaction title (Fig. 34).

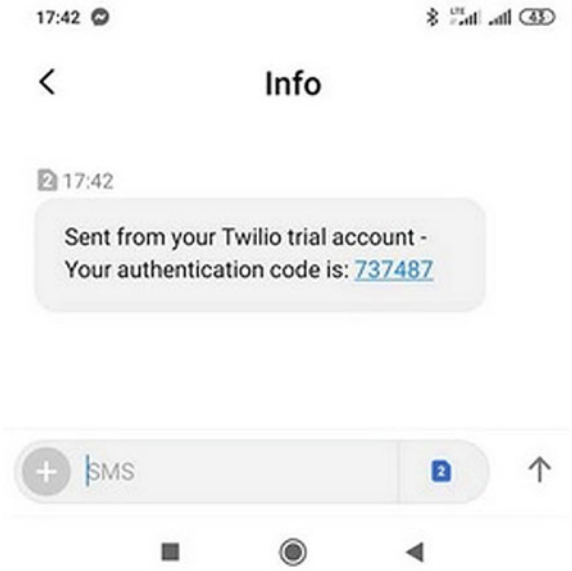

Fig. 30 SMS authorization

Fig. 31 Entering authentication code

Fig. 32 Entering authentication code incorrectly 3 times

The fields with the account number and amount are checked to see if they have been correctly completed—whether the account number exists and whether the balance allows for a transfer of this amount. In the case of an incorrect invoice number or insufficient amount, appropriate comments will be displayed (Fig. 35).

If the transaction was successful, a notification will be sent to the user's email address (Fig. 36).

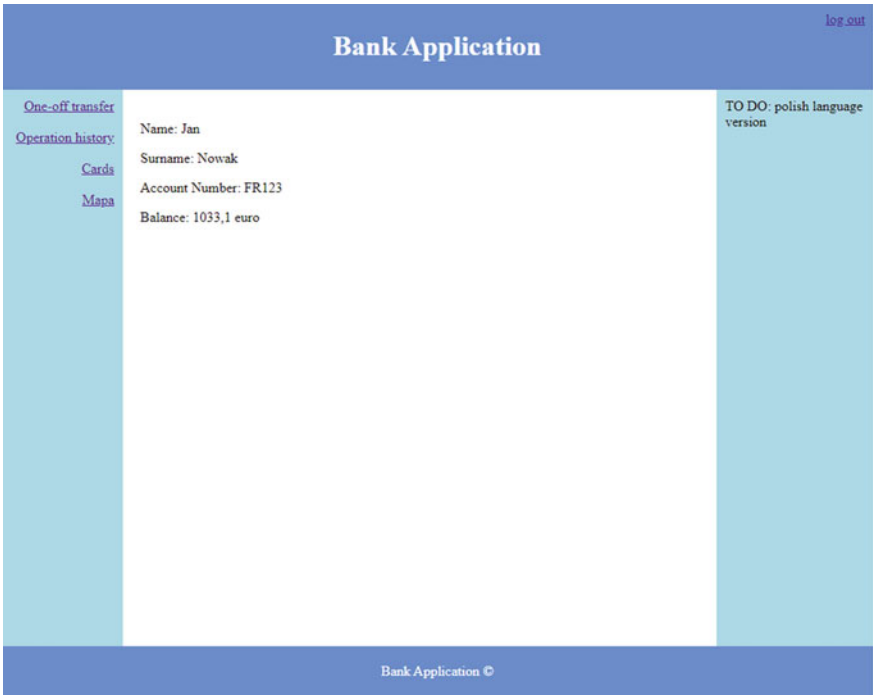

Fig. 33 Home page

4.4.5 Transaction History

By entering the "Transaction history" tab we will see a window such as the one below—a list of completed transactions with account number, amount and transaction title (Fig. 37).

4.4.6 Cards

By entering the "Cards" tab, a window opens that allows you to manage your cards. The active card number is displayed, as well as the option to order and deactivate the card (Fig. 38).

The user by clicking on "Deactivate card" deactivates the currently active card. If the user does not have an active card, he can order it by clicking on "Order new card". If the user currently has an active card, he will be asked to deactivate the old one before placing an order for a new card (Fig. 39).

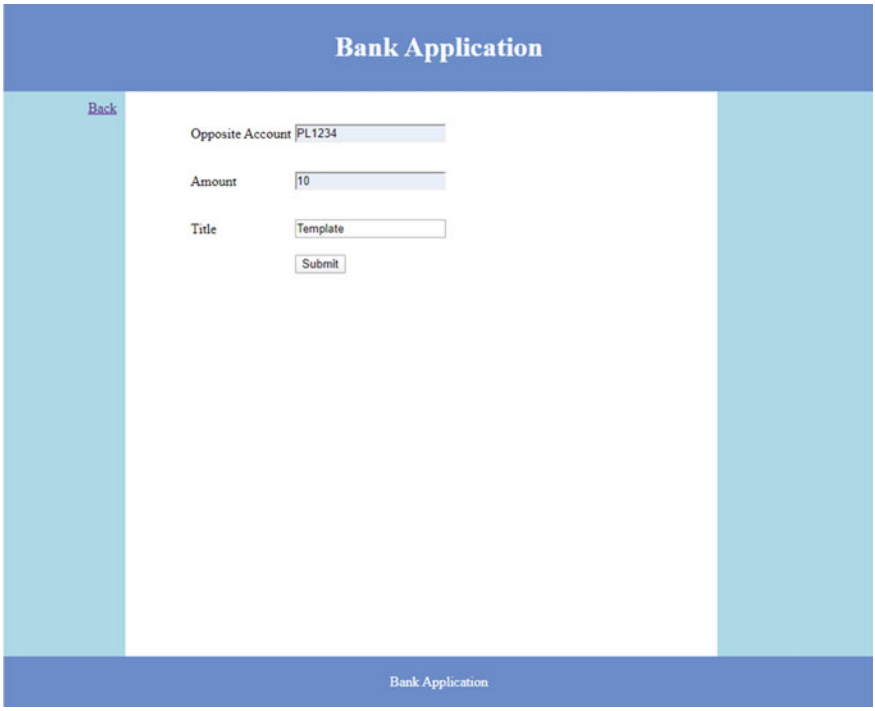

Fig. 34 Make a transfer

4.4.7 ATMs

If the user wants to display the map with selected ATMs in the area, select "Map" from the menu. After entering the tab, a map page will be displayed (Fig. 40).

5 Conclusion

The "smart banking" banking application we designed works in accordance with our assumptions and expectations.

Many of the facilities used in our application are a classic on today's banking market. Having an account for electronic banking is not only a privilege, but often a duty. Currently, most employers pay salaries to bank accounts. More and more business activities are conducted on the Internet. if we want to function efficiently in today's world, we need a bank account with a login and password.

Of course, the account, login and password are just the beginning. Important features are the functions that the bank can perform for us. The bank not only manages our account, but also gives us a number of relevant information. This information

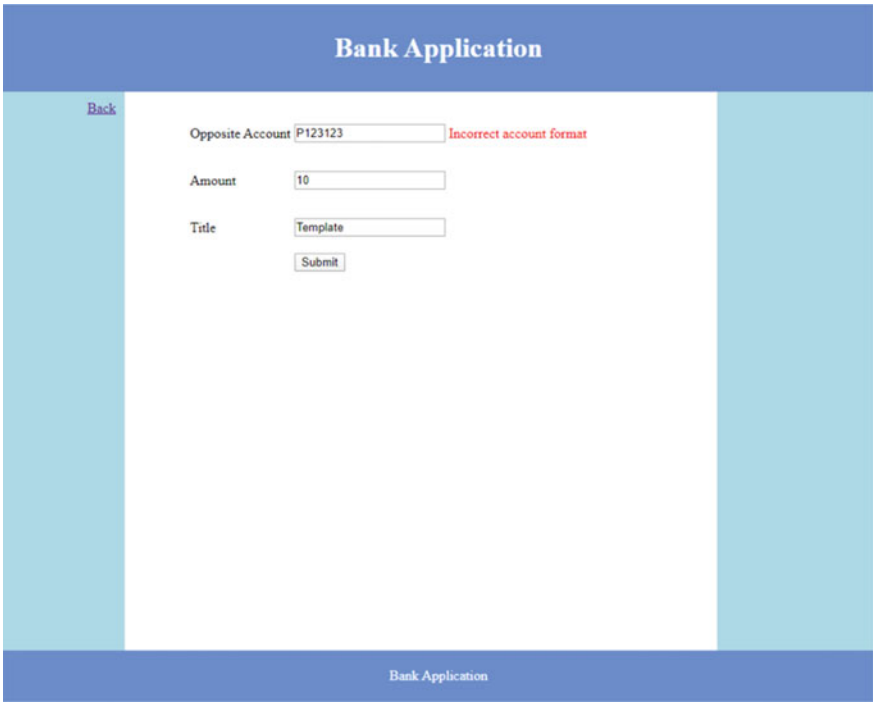

Fig. 35 The fields with the account number and amount are being checked

includes: account balance or making transfers. Our bank also has such facilities as the ability to view transaction history. And most importantly in this case, our application does not delete this information after the end of the accounting year, like some banks. Our bank stores full information about the transaction history. We are aware that this is a certain burden on the system, but our client's satisfaction is the most important for us. In addition, in the era of rapidly developing IT solutions, the issue of system load is the most to be solved.

One of the elements that we wanted to pay special attention to in the system, which is the banking application, is the issue of security. Every day we hear about cases of hacking bank pages. Many e-banking clients have already been robbed. A new solution recently is double user verification. More and more banks are using this solution. However, when it comes to Polish electronic banking, it is not yet a standard. There are still banks on the Polish market that do not use double verification. We decided to meet the expectations of customers and used additional verification in the form of sms code. We recognize that some users may not share our approach to security. There are still users in this world who are not aware of the dangers lurking in the cyber world. These users may find the solution we propose a nuisance. This solution 'steals' us a few extra seconds from our precious day. However, we strongly believe that it is only a matter of time before these users understand that security

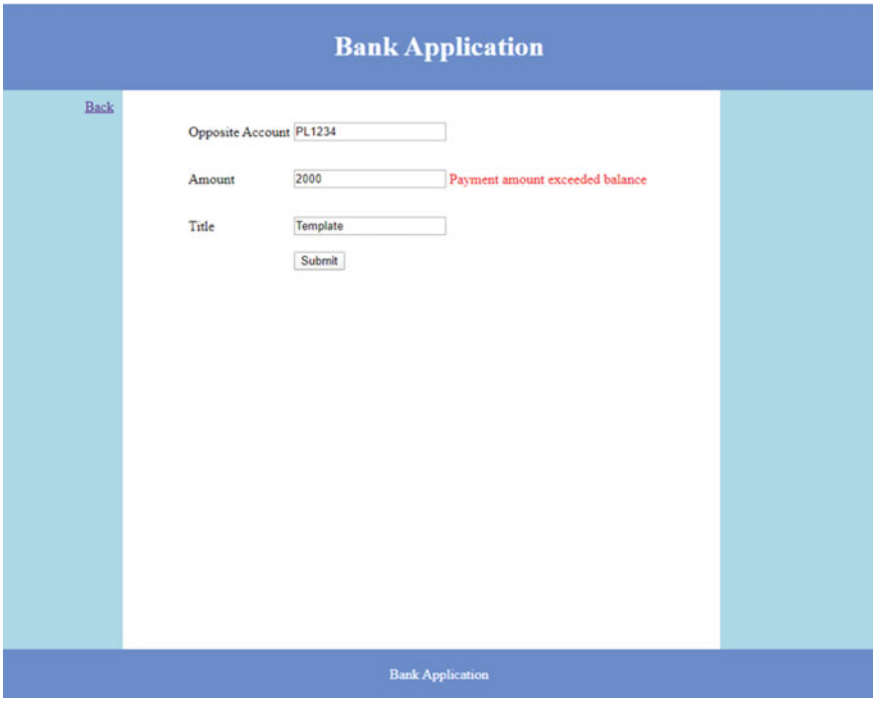

Fig. 36 The fields with the account number and amount are being checked

is the most important thing these days. The issue of speed should be a secondary role here. It should be remembered that many citizens in banks keep all the financial assets of their lives. Poles have not yet learned to invest their money. They don't invest them in shares or bonds. Instead of keeping money in the proverbial sock, many of them put them in a bank. And it is the responsibility of financial institutions to take care of people's property.

Another important aspect we decided to take care of is the need for information. In today's world, this information is the driving force of global economies. However, let's not forget that it is people who build this economy. Given the above, we decided to provide them with information about ATMs in the immediate vicinity. We know that most people are visual people. Therefore, we decided to visualize the above information. The list of ATMs alone can be helpful. It should be remembered that we care about clients from all over the world. Our customer may be a tourist who does not know the street names. For him, the most convenient solution will be the placement of ATMs on the map. This will allow him to reach his destination faster. This convenience is not only for tourists, but we believe that they can appreciate them the most. In addition, most citizens do not know all corners of their city. Therefore, the map is definitely a better solution than the classic list of points.

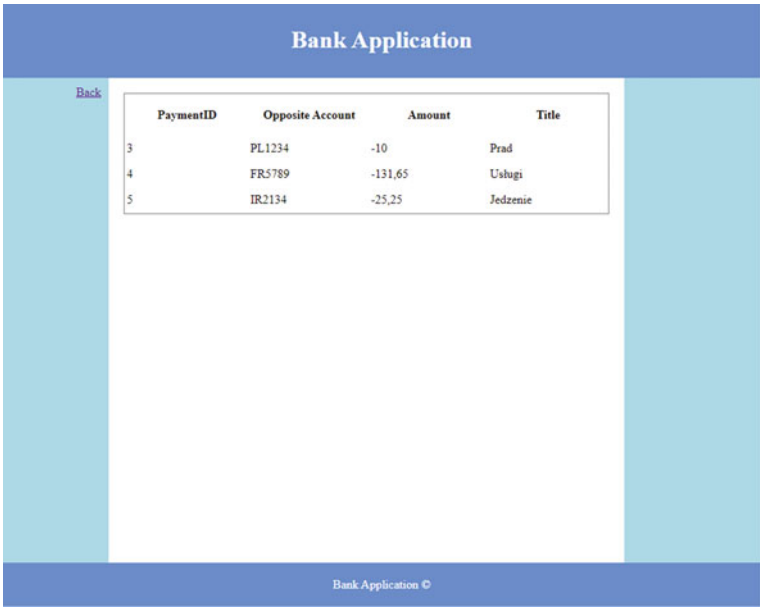

Fig. 37 Transaction history

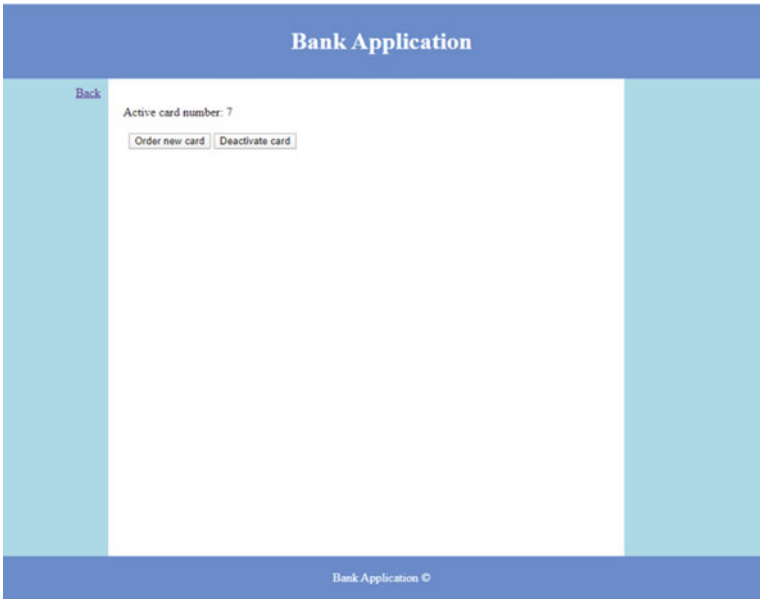

Fig. 38 Cards

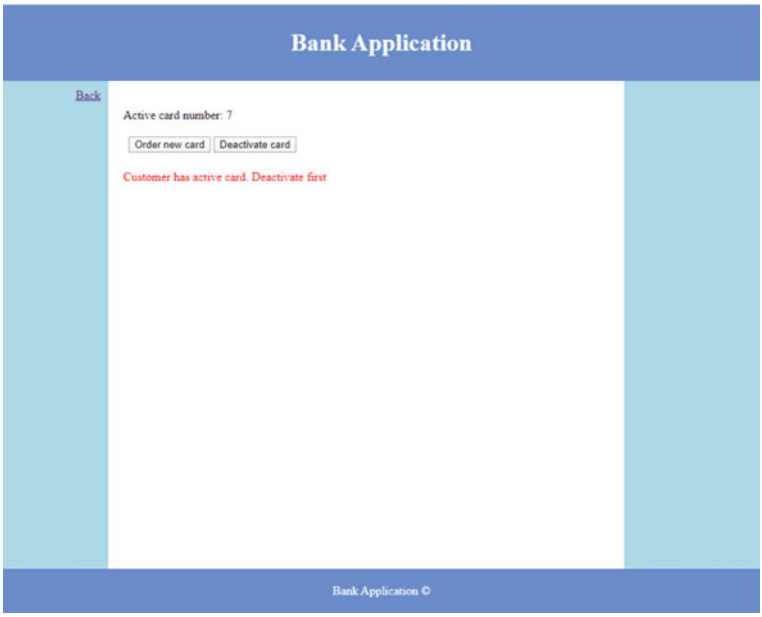

Fig. 39 Deactivating card

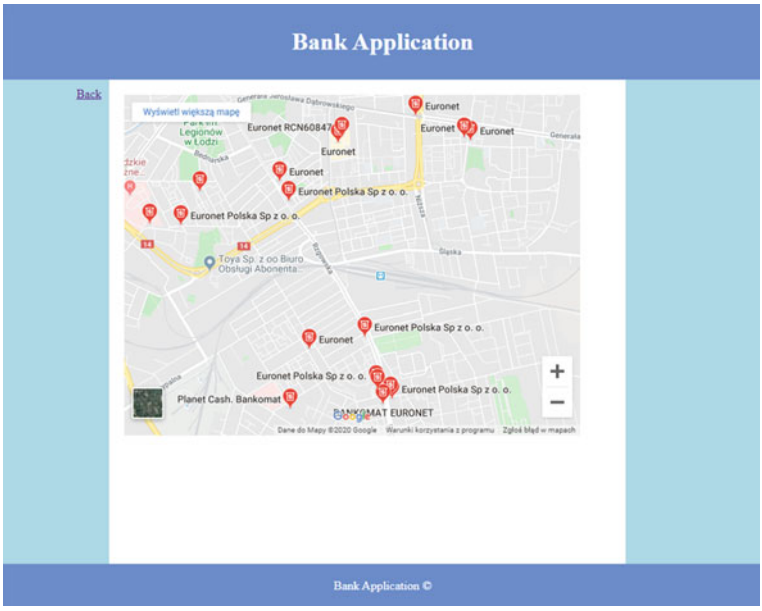

Fig. 40 Searching nearest ATMs

In our opinion, our application will meet the expectations of the modern customer and solve several problems that lie on his shoulders.

References

1. Zaleska, M.: Characteristics of the banking system—institutional condition (2018). Retrieved from: https://cor.sgh.waw.pl/handle/20.500.12182/470?show=full. Accessed 19 Nov 2019
2. Iwański W.: Bank Account Agreement Covered by Internet Banking from the Point of View of the New Regulation of Payment Services. C.H.Beck, Warsaw (2014)
3. Junejo, M., Laghari, A., Jumani, A., Karim, S., Khuhro, M.: Quality of experience assessment of banking service. Int J Inform Eng Electron Bus (IJIEEB) **12**(6), 39–50 (2020). https://doi.org/10.5815/ijieeb.2020.06.04
4. Zarańska, K., Zborowski, M.: Characteristics of Electronic Banking (2018). Retrieved from: https://www.ksiegarnia.beck.pl/media/product_custom_files/1/7/17376-bankowosc-elektroniczna-istota-i-innowacje-andrzej-gospodarowicz-fragment.pdf. Accessed 19 Nov 2019
5. Chmielarz, W.: Electronic Banking Systems. Difin, Warszawa (2005)
6. Polasik, M.: Conditions and Prospects for the Development of Retail Internet Banking in Poland. Harmonization of Banking and Insurance on a national and European scale, pp 120–128 (2007)
7. Khan, M., Mahmood, W.: Technology adoption in Pakistani banking industry using UTAUT. Int J Inform Technol Comput Sci (IJITCS) **14**(1), 32–42 (2022). https://doi.org/10.5815/ijitcs.2022.01.04
8. Elhassan, R., Yousif, A., Suliman, T.: Assessment of knowledge management application in banking sector of Sudan: case study farmer's commercial bank. Int J Inform Eng Electron Bus (IJIEEB) **13**(4), 1–19 (2021). https://doi.org/10.5815/ijieeb.2021.04.01
9. Nosowski, A.: The genesis of electronic banking. In: Electronic Banking. Polskie Wydawnictwo Ekonomiczne, Warsaw (2005)
10. Jaszczura, M., Józefowicz, A., Kucharska, M., Maszkowska, M., Misiak, M., Otrembski, P.: Smart Banking Application. Technical University of Łódź, Extramular studies, academic year 2019/2020
11. Boczoń, W.: PRNews.pl report: Mobile banking market - Q4 2015 (2016). Retrieved from: http://prnews.pl/raporty/raport-prnewspl-rynek-bankowosci-mobilnej-iv-kw-2015-6552323.html. Accessed 19 Nov 2019
12. Polasik, M.: Internet Banking. Foundation for Banking Education and Research, Warsaw (2002). http://www.swo.ae.katowice.pl/_pdf/62.pdf
13. Zimba, A.: A Bayesian attack-network modeling approach to mitigating malware-based banking cyberattacks. Int J Comput Netw Inform Secur (IJCNIS) **14**(1), 25–39 (2022). https://doi.org/10.5815/ijcnis.2022.01.03
14. Ojeniyi, J., Edward, E., Abdulhamid, S.: Security risk analysis in online banking transactions: Using diamond bank as a case study. Int J Educ Manage Eng (IJEME) **9**(2), 1–14 (2019). https://doi.org/10.5815/ijeme.2019.02.01
15. Banking of the Future will be perfectly Tailored. Traditional Banks may lose their dominant Position in the Market (2018). Retrieved from: https://prnews.pl/bankowosc-przyszlosci-bedzie-idealnie-szyta-miare-tradycyjne-banki-moga-utracic-dominujaca-pozycje-rynku-437028. Accessed 19 Nov 2019
16. ChallengeRocket: Banking of the future is about innovations that will completely change the world of personal (2018)
17. A Brief History of Bitcoin & Cryptocurrency (2019). Retrieved from: https://www.ledger.com/academy/crypto/a-brief-history-on-bitcoin-cryptocurrencies/. Accessed 3 Jan 2020
18. Frankenfield, J.: Cryptocurrency. Retrieved from: https://www.investopedia.com/terms/c/cryptocurrency.asp. Accessed 3 Jan 2020

19. Cryptocurrency. Retrieved from: https://www.investopedia.com/terms/c/cryptocurrency.asp. Accessed 3 Jan 2020
20. Frankenfield, J.: Cryptocurrency. Retrieved from: https://www.investopedia.com/terms/c/cryptocurrency.asp. Accessed 3 Jan 2020
21. Yellin, T., Aratari, D., Pagliery J.: What is bitcoin? Retrieved from: https://money.cnn.com/infographic/technology/what-is-bitcoin/index.html. Accessed 3 Jan 2020
22. Młynarz, P.: Blockchain—hope for better banking. Retrieved from: https://www.fxmag.pl/artykul/blockchain-nadzieja-na-lepsza-bankowosc. Accessed 3 Jan 2020
23. The future of blockchain technology in banking applications. Retrieved from: https://antyweb.pl/blockchain-zastosowania-bankowe/#. Accessed 3 Jan 2020
24. Rossolillo, N.: Types of Cryptocurrency. Retrieved from: https://www.fool.com/investing/2018/04/05/types-of-cryptocurrency.aspx. Accessed 3 Jan 2020
25. CoinMarketCap. Retrieved from: https://coinmarketcap.com/. Accessed 3 Jan 2020
26. WalletInvestor. Retrieved from: https://walletinvestor.com/forecast/bitcoin-prediction. Accessed 3 Jan 2020
27. Krzysztoszek, M.: Electronic Banking in Theory and Practice. Polish Financial Supervision Authority, Warsaw (2017)
28. Journal Office: PFSA from 2013, item 5; Recommendation D constitutes an attachment to the Resolution No. 7/2013 of the Polish Financial Supervision Authority of 8 January 2013 regarding the issue of Recommendation D regarding the management of areas of information technology and ICT environment security in banks
29. Recommendation D regarding the management of risks associated with IT and telecommunications systems used by banks, issued by the Commission for Banking Supervision in the form of a resolution of December 11, 2002
30. Syerov, Y., Somych, N., Ortynskyy, V., Zakharchenko, A., Lozynska, I.: E-banking: Commerce and legal aspects. In: Proceedings of the Symposium on Information Technologies & Applied Sciences (IT&AS 2021), Bratislava, Slovak Republic, March 5, 2021. CEUR Workshop Proceedings. Vol. 2824, pp 152–162
31. Journal Office: PFSA from 2015, item 56; the Recommendation constitutes an attachment to the Resolution No. 584/2015 of the Polish Financial Supervision Authority of November 17, 2015 regarding the issue of a Recommendation on the security of payment transactions carried out on the Internet by banks, national payment institutions, national electronic money institutions and cooperative savings and credit unions
32. Security of Electronic Banking (2015). Retrieved from: https://obserwatorium.biz/wp-content/uploads/2018/11/2_PL.pdf. Accessed 19 Nov 2019
33. The Threats of modern electronic Banking (2017). Retrieved from https://prnews.pl/zagrozenia-wspolczesnej-bankowosci-elektronicznej-374213. Accessed 7 Dec 2019
34. What Millennials and Generation Z expect from their Banks and Service Providers. Retrieved from: http://global.wellsfargo-bank.com/wfinsights-articles-millenials. Accessed 7 Dec 2019
35. Generation Z: The Digital (R)evolution. Retrieved from: https://www.bbva.com/en/news/general/generation-z-digi-tal-revolution/. Accessed 7 Dec 2019
36. Molodetska, K., Veretiuk, S., Gregus, M., Fedushko, S., Syerov, Y.: Simulating the interaction of social internet services actors using irregular attractors. Procedia Comput Sci **198**, 688–693 (2021)
37. The Millennial Disruption Index. Retrieved from: http://www.millennialdisruptionindex.com/. Accessed 7 Dec 2019
38. Millennial Banking Customers: Two Myths, One Fact. Retrieved from: http://www.gallup.com/businessjournal/187364/millennial-banking-customers-two-myths-one-fact.aspx. Accessed 7 Dec 2019
39. They do not need a Car or an Apartment. This is a New Challenge for Banks. Retrieved from: http://tvn24bis.pl/pieniadze,79/ekf-pokolenie-millenialsow-ogromnym-wyzwaniem-dla-sektora-bankowego,652542.html. Accessed 7 Dec 2019
40. Nocoń, B., Garbus, J., Pekao, B. S. A.: New generations of clients in banking. In: Challenges of IT Banking, pp 11–22 (2017)

41. Risk Management. Retrieved from: https://www.cyberustawa.pl/index.php?p=1_14&gclid=CjwKCAiA6bvwBRBbEiwAUER6JYfEHBTlYeymfE5s-kmzbecISmchwFzEu-L_6R7P0kJ8rmd9kArO7xoCXgQQAvD_BwE. Accessed 3 Jan 2020
42. Risk Management. Retrieved from: https://mfiles.pl/pl/index.php/Zarz%C4%85dzanie_ryzykiem. Accessed 3 Jan 2020
43. Basel Committee on Banking Supervision, Risk Management Principles in Electronic Banking, (2001). Retrieved from: https://www.knf.gov.pl/knf/pl/komponenty/img/electronic.pdf. Accessed 7 Dec 2019
44. Twillio. Retrieved from: https://www.twilio.com/learn/twilio-101/what-is-twilio. Accessed 9 Jan 2020

Risk Analysis of Supply Chain Quality Management in Food Industry

Asma AzizZadeh, Hadi Balouei Jamkhaneh, and Ahmad Ghorbanpour

Abstract Nowadays, due to the rapid changes in the competitive market and the uncertainty caused by dynamic work environments, it is highly crucial to use supply chain quality management in order to synchronize the interorganizational borders with customers and suppliers to meet customers' needs. The variety of risks through the supply chain and also the different effects they have on the supply chain function make it difficult for the managers to decide in the competitive conditions. The main aim of the project is to identify and analyze the risks related to supply chain quality management. To do this, the experts' opinions from university and food industry and also fuzzy cognitive map (FCM) were used. The findings reveal that 30 risks related to supply chain quality management can be classified into three groups, namely upstream quality management, internal quality management and downstream quality management. The analysis showed that ICT infrastructure, choosing supplier, social responsibility, and supplier reliability are the pivotal risks in supply chain quality management in food industry.

Keywords Quality management · Risk analysis · Supply chain quality management · Fuzzy cognitive map · Food industry

1 Introduction

These days, companies heavily depend on their suppliers to manufacture a product or provide services. This has made controlling and monitoring the processes quality out of the organization sophisticated. Therefore, an approach is needed to manage the implementation of the processes through the supply chain and also guarantee the quality demanded by the stakeholders. In the traditional approach, companies used approaches such as publishing rules and regulations and quality inspection of the input (e.g., raw materials) to provide quality; however, implementing these strategies

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does not necessarily guarantee the required stability in meeting stakeholders' expectations. As companies are entering global markets and compete with international companies, and there are emerging issues related to new technologies, customers, and intraorganizational factors, meeting the quality required by the stakeholders in all aspects of supply chain is crucial.

Quang, Sampaio [1] described supply chain quality management as merging and coordinating all parts of supply chain. To accomplish the coordination, they first divided processes and parts of supply chain into three categories: upstream, internal, and downstream processes. They also determined the different aspects of each category and the role they play in the supply chain quality. The difficulties involved in measurement of supply chain quality (which was a major problem in intraorganizational factors) made Zeng, Phan [2] to concentrate on this issue in their studies. They investigated critical factors of SCQM and their effects on quality and also determined the factors that have effect on the quality in upstream, internal, and downstream levels. A study conducted by Zu and Kaynak [3] revealed that sharing information can have a significant effect on improving the performance of supply chain. One important factor in the success of supply chain is the ability to manage big data and advanced interorganizational information system, which can have significant effects in improving information exchange. Therefore, information technology has turned into one of the key areas in improving SCQM. Studying them can show the role of information architecture using services such as IOT, RFID, SOA and the effect of information architecture on supply chain quality management [4]. With the globalization of communication between the aspects of supply chain, there will be challenges ahead of supply chain quality management. Therefore, Talib, Rahman [5] suggested the developed EFQM model to address the concerns in the effective implementation of supply chain quality management. Their findings suggest that global leadership and human resource management are among the most important factors in supply chain management. Kuei, Madu [6] argue that communication and coordination are inseparable parts of global SCQM and in order to do it successfully, it is important to present the approaches related to SCQM critical factors and thoughtful discourse. In another study, Kuei, Madu [7] suggest that there are four main concerns in implementation of supply chain quality management, which should be taken into consideration thoroughly; otherwise, the supply chain quality management will not be implemented successfully. These concerns include: complex information systems, inability to manage supply chain inventory, lack of coordination among different sectors of supply chain, trust issue among supply chain members. The increase in the competitive market and dependence among supply chain members can lead to disorders in the supply chain and the negative outcome can influence the financial output. In these cases, understanding different methods of quality management in supply chain can have significant positive effects on the performance of a firm and also on the improvement of disorders in supply chain [8]. Another important factor in the successful implementation of supply chain quality management is sharing knowledge and useful information in supply chain components. Although using modern technology can have a positive effect on supply chain management,

distorting knowledge and information can disrupt supply chain management to some extent [9].

According to the definition of supply chain quality management, effective merging and coordination among the components of supply chain is crucial and the function each unit has can affect other units. Therefore, in order to implement the quality management effectively throughout the supply chain in dynamic and unpredicted conditions, the risks and failures in supply chain quality management should be identified. Also, the relationship among each unit should be investigated and the effect that they have on other parts of the supply chain needs to be analyzed. The review of the literature showed that there have been few studies conducted in this subject. Some studies investigate the effect of supply chain quality management on the function of the organization [10]. Others have identified and analyzed the risks involved in supply chain management [11]. Some studies have also been conducted on the integrity of quality management and the supply chain processes within the organization [12, 13]. However, these studies have not provided us with a comprehensive and systematic approach to the analysis of the risks involved in supply chain quality management to meet the needs of stakeholders. Due to the variety of risks throughout the supply chain and the different effects they might have, it is important to identify and analyze the risks in terms of effects they have on the managers' decisions in the competitive conditions and provide solutions to eliminate or reduce the risks. Therefore, the main aim of this study is to comprehensively identify and analyze the risks related to supply chain quality management. To do this, the experts' opinions from university and food industry and also fuzzy cognitive map (FCM) were used.

2 Literature Review

The quality of the products or services are in direct relationship to the quality of the input, and because of the interactions among different chains, if an unpredictable disorder happens in providing a service or product, the company may not be able to meet up with the quality expected, which will lead to the failure in achieving the strategic objectives. Therefore, it is essential to have an integrated approach to meet the quality throughout the supply chain. In this regard, SCQM is one of the approaches that focuses on the current practices in supply chain to help meet the competitive advantage based on the high-quality output [3, 14]. The uncertainty caused by not observing the quality management rules and thus not being able to meet the stakeholders' needs can lead to some risks in the supply chain. This will result is inconsistency in reaching objectives and collapse of supply chain. Also, providing products with low quality will negatively affect the reputation of the brands. These risks will lead to losing market share and finally, the companies will be out of the market. Merging effective actions and monitoring the appropriate implementation, SCQM has guaranteed output quality, reduced risks regarding unpredictable events, caused competitive market, decreased costs, made production time efficient, improved the quality of the product [4].

In a study, Kuei, Madu [15] investigated the relationship between supply chain quality management styles and organizational performance. The results of their survey suggest that organizational performance can be improved by the appropriate implementation of supply chain quality management. Moreover, according to their results, factors such as leadership, senior management, instruction, product design, supplier quality management, high-quality report, staff relationships, customers relationships, benchmarking, supplier choice, and supplier involvement have a direct relationship with the improvement of organizational performance quality. Using experimental data from Hongkong and Taiwan, Lin, Chow [16] evaluated the factors effective on the supply chain quality management. The responses from experienced managers showed that QM quality management styles have a significant relationship with supplier choice and involvement and lead to the rise in commercial opportunities and customer satisfaction [17]. In a study, Robinson and Malhotra [17], using a definition supply chain management by SCM, challenged their previous studies and argued the need for change from performing quality methods in the product-centered traditional approaches to customer-centered ones. In the case studies they did and the experience of working with companies and based on the ISO9001, they suggested QUALITY-SCM which is a benchmark to assess the previous and upcoming proceedings. According to this framework, the subjects in SCQM consists of intraorganizational coordination (traditional organization quality management) and concentration on national supply chain, the link between supply chain and quality and finally on international supply chain. In another study, Kuei, Madu [7] suggested a strategic framework for development of supply chain quality management. In this framework, the approaches based on the insight and gaps and the actions and reactions to each approach was considered. According to this study, 5 stimulants of supply chain were identified, namely supply chain competence, critical success factors (CSF), strategic components, supply chain quality (SCQ) proceedings and approaches. Then, using AHP hierarchical analysis, these stimulants were developed [18]. Foster Jr [14] defines supply chain quality management and understanding the effect of increasing the emphasis of supply chain management on quality management performance and determining key variables of quality management content. The ever-increasing emphasis on supply chain quality management made researchers revise the predetermined frameworks, so according to SCQM, an approach was defined to improve the performance of the system with the upstream and downstream processes [18]. Foster Jr, Wallin [18] presented a framework for SCQM supply chain quality management to expand the supply chain in the traditional view and quality management. To achieve this framework, he used three groups of variables (design variables, system variables, and problem-solving and decision-making methods). He tried to improve the interaction between the subsystem components in a supply chain [6]. In a study, Talib, Rahman [5] studied the comprehensive quality management and supply chain management styles. In their study, 8 components were mentioned to perform comprehensive quality management within an organization, including management commitment (management leadership and support), focus on customer (customer satisfaction and orientation), education, efficiency and continuous improvement, supplier management (supplier relationships, supplier quality and supplier cooperation), staff

cooperation, product/service design and products/services guidelines. Among these, management commitment and focus on customer were mostly mentioned in TQM and SCM strategies. Through continuous management and improvement in customer service, TQM and SCM lead to customer satisfaction and improvement in system performance.

Xu [4] argues that operations managers tend to manage supply chain using approaches such as ISO9000 and supplier evaluation, while supply chain managers usually prefer to expand the supplier and take complaints more into consideration. As quality performance is a necessity for supply chain management, companies and organizations should have access to effective data in order to find out supply chain needs, and hence information architecture is taken into consideration. In a study, Xu [4] argues that appropriate information share is necessary to improve the supply chain management performance and integrity among its members. One main issue in supply chain quality management is prediction and control of the factors effective on supply chain, which result from lack of appropriate data. Also, the increase in the components of supply chain will add to the complexity. Therefore, sharing information and the appropriate architecture regarding quality management in supply chain can be a vital competitive advantage.

Quality management in supply chain and comprehensive management, which are performed in organizations to improve the quality and create competitive advantage, have attracted many researchers. For example, Kaur, Singh [19] investigated the effect of merging these two approaches in organizations. Reviewing the literature, they identified the critical factors of comprehensive quality management and supply chain management separately, and ultimately, they suggested a conceptual model for supply chain quality management. The results reveal that senior management quality and commitment, focus on customers, information flow, and supplier participation are similar between comprehensive quality management and supply chain management. They argued that merging these two approaches and forming supply chain quality management has the highest impact on organizational performance. By increasing the knowledge and instruction, Supply chain quality management (SCQM) positively affects supply chain performance and lead to the rise in supply chain operations quality [20]. To identify the supply chain quality management performance, it is important to know what the criteria for quality are. Karamouz, Kahnali [21] investigated the studies regarding supply chain quality management and the effect on supply chain performance. Analyzing and merging the data in other studies, they provided some criteria to evaluate quality control in three levels: supplier, customer, and company. Quality management in supply chain refers to approaches and strategies that a company uses to merge and coordinate the upstream (e.g., suppliers) and downstream (e.g., customers). Due to the vast use of supply chain quality management, Iman et al. investigated the ways in which supply chain quality management can affect supply chain performance with the agile intermediary role of supply chain and innovative supply chain capabilities. In this regard, 284 random samples in different industries were surveyed and a quantitative model based on the gathered data was designed. In the end, the hypotheses were investigated using structural equation modeling (SEM). Their findings showed that supply chain quality

management can facilitate agility capabilities, innovate supply chain, develop these abilities, and indirectly affect the supply chain management performance [22]. One of the main aims of performing supply chain quality management is to guarantee success throughout the supply chain management. To do this, a variety of methods are used some of which may not be useful due to the human error. As the cooperation among supply chain members have become globalized, it is difficult to maintain the framework related to the suppliers and achieve the requirements to build trust. Li, Maiti [9] address the potentials of blockchain in industry, especially in IoT-based (Internet of Things) sensors. Their study deals with the innovative performance of blockchain in supply chain quality management. Blockchain is a reliable format to achieve the open manufacture objectives in the vast network of supply chain. The everyday expansion and complexity of blockchain provides the need for more thorough monitoring mechanisms to ensure the quality performance throughout the supply chain. Also, by referring the required data from production stage and saving them in the blockchain, Internet of Things guarantee the quality at the production stage for the final customers. Due to the features such as building trust, security, transparency in transactions, efficiency improvement, cost reduction, tracking the data source and sharing it, blockchain can be a useful option to work alongside IoT in performing SCQM in industries. Because of the expansion of supply chain and the global cooperation in the global competitive market, a significant physical dispersion is noticed among the supply chain members. This will entice companies and organizations to move toward digital supply chain. This digitalization can add to the complexity of decision-making, and makes manufacturing companies expand their supply chain quality management systems. Should companies want to seek the expansion, choosing an appropriate digital supplier is important. In a study, Jahantigh and Dehghani [23], using Game Theory approach, modeled the applicable strategies in supply centers for medical equipment used in hospitals. Also, considering self-education in Markov chain, they simulated supply chain environment with the aim of competition with other firms in providing the medical equipment in hospitals. In their study, they used the results of simulated model and calculated the incomes and also considered the possibility of change in selecting different strategies in different firms. These reinforced the importance of encouragement and punishment in medical equipment supply chain quality management to motivate suppliers to use a high-quality strategy. In another study, Ajili [24] investigated supply chain quality management in gas industry. He prioritized the components of supply chain quality management based on the level of importance they have in gas industry using fuzzy analytic hierarchy process and also experts' opinions. Finally, using fuzzy DEMATEL method, a cause-effect model from the top components in gas industry was presented. They argued that there are 7 components determined by experts, including focus on customers, supplier quality management, quality leadership in supply chain, quality strategies in supply chain, process approach in supply chain quality management, development of quality information technology and systems in

supply chain, and human resource manager in supply chain. Among these components, they found supplier quality management, quality approaches, quality information technology and systems, and quality leadership in supply chain are of utmost importance and should be taken into serious consideration in gas industry.

3 Research Methodology

The methodology used in this study was descriptive survey. The population involved in this study include food industry managers in Bushehr province. The samples were chosen using judgmental purposive nonrandom sampling according to the experimental and theoretical science criteria in the subject. The required data in this study were collected using researcher-made questionnaire. In order to evaluate the validity of the questionnaire, content analysis method was used. The questionnaire was given to 10 research experts to evaluate the validity, and they confirmed the validity of the questionnaire. In order to evaluate the reliability, contingency coefficient was applied. The reliability was found to be 0.84, showing appropriate reliability. Generally, risk analysis of supply chain quality management is shown in Fig. 1 using fuzzy cognitive map.

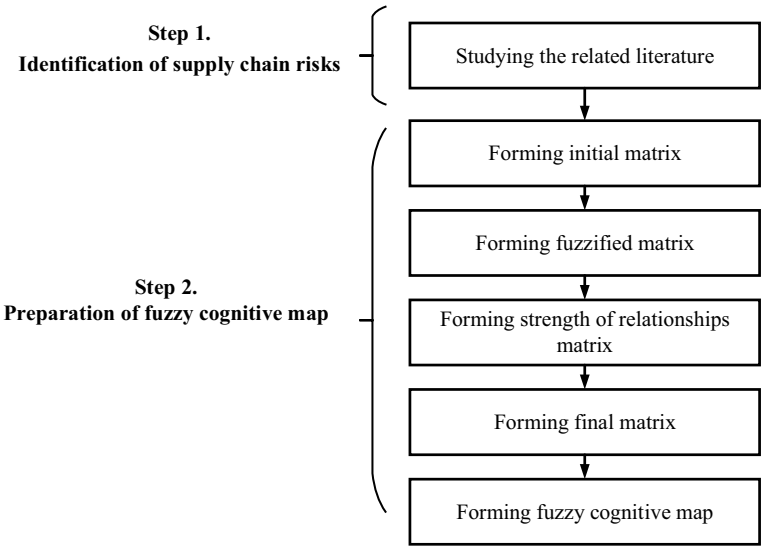

Fig. 1 Research structure

The methodology is divided into three steps:

Step 1. identifying supply chain quality management risks in food industry

In this study, the literature was studied to identify supply chain quality management risks. Then, using content analysis approach, the common risks were merged and those with low probability were removed.

Step 2. creating fuzzy cognitive map

Fuzzy cognitive map is a simple method to model complex mathematical systems [25]. Fuzzy cognitive map is used to analyze and contribute to the decision-making process by considering the random links between the related concepts [26]. By calculating initial, fuzzified, strength of relationship and final matrix, a fuzzy cognitive map can be created [27].

Initial matrix: $m * n$ matrix, where n is the number of variables and m is the number of interviewees. Each O_{ij} in the matrix shows the importance of person j for variable i. The vector related to the concepts of each row is shown as v_i.

Fuzzified matrix: In this section, numerical vectors v_i change to fuzzy sets in [0.1]. To do this, the maximum amount of v_i is calculated as follows, assuming $X_i = 1$.

$$\mathrm{Max}\left(O_{iq}\right) \rightarrow X_i\left(O_{iq}\right) = 1$$

Then, the minimum amount of v_i is calculated as follows, assuming $X_i = 0$.

$$\mathrm{Min}\left(O_{ip}\right) \rightarrow X_i\left(O_{ip}\right) = 0$$

Following that, the other amounts of v_i in [0.1] is calculated as follows.

$$X_i\left(O_{ij}\right) = \frac{O_{ij} - \mathrm{Min}\left(O_{ip}\right)}{\mathrm{Max}\left(O_{iq}\right) - \mathrm{Min}\left(O_{ip}\right)}$$

where $X_i(O_{ij})$ is membership degree (value) of O_{ij} to v_i.

In order to determine the membership degree, it is vital to determine a minimum and maximum amount. If v_i of numerical vector of elements of m is related to i, $i = 1, 2, \ldots, m$, and O_{ij} is as v_i elements, the minimum and maximum amounts will be determined as follows:

$$\forall_{j=1\cdots m} O_{ij}\left(O_{ij} \geq \alpha_u\right) \rightarrow X_i\left(O_{ij}\right) = 1$$

$$\forall_{j=1\cdots m} O_{ij}\left(O_{ij} \leq \alpha_l\right) \rightarrow X_i\left(O_{ij}\right) = 0$$

Other elements of v_i are estimated in [0.1]. Using the above process, the numerical vectors will turn into a fuzzy set. Threshold value is usually determined as 80 and 20.

Strength of relationships matrix: it is a [n × n] matrix. Concepts will form the rows and columns of this matrix. In this matrix, each element shows the strength of relationship between i and j, shown as s_{ij}. It can range from [−1. +1]. There are three relationships for s_{ij}.

- $s_{ij} > 0$ shows the positive causality (positive) among the concepts. It means that the increase in concept i will increase j.
- $s_{ij} < 0$ shows the opposite causality (negative) among the concepts. It means that the increase in concept i will decrease j.
- $s_{ij} = 0$ shows that there are no relationships between i and j.

Therefore, when determining s_{ij}, these points should be taken into consideration.

- s_{ij} sign which shows the relationship between i and j.
- s_{ij} strength which shows how each concept affects the other.
- Causality direction, which shows i causes j and the vice versa.

Determining strength of relationships: the proximity relationship of vectors v_1 and v_2, calculated by the similarity of these vectors, shows the strength of relationship between concepts 1 and 2 and these vectors. The proximity relationship of two vectors is based on the distance between the two sectors. Schneider, Shnaider [28] suggested an approach to calculate the similarity between the two vectors. Calculating the relationship between the vectors with a direct relationship is different from those with an opposite relationship. If v_1 and v_2 have a direct relationship, then their closest relationship for each j is $d_j X_1(V_j) = X_2(V_j)$. The distance between element j of v_1 and v_2 vectors is calculated as follows.

$$d_j = \left|X_1(V_j) - \left(1 - X_2(V_j)\right)\right|$$

And the average distance (AD) between v_1 and v_2 vectors is calculated as follows.

$$AD = \frac{m \sum_{j=1} \left|d_j\right|}{m}$$

The similarity or proximity of S among the two vectors is shown as follows.

$$\mathrm{S} = 1 - \mathrm{AD}$$

When $S = 1$, there is full similarity, and when $S = 0$, it shows no similarity. If v_1 and v_2 vectors have opposite relationship, the similarity between v_1 and v_2 vectors is calculated as follows.

$$d_j = \left|X_1(V_j) - \left(1 - X_2(V_j)\right)\right|$$

Final matrix: when strength of relationships matrix is completed, some data can be misleading, as some relationships between the presented concepts may not be meaningful in real life. Therefore, the unnecessary relationships can be deleted based on the experts' opinions. This matrix will be the final matrix which will act as the basis to draw fuzzy cognitive map.

Graphic representation of the fuzzy cognitive map: Graphic representation of the final matrix as fuzzy cognitive map will provide a purposeful map for the factors and concepts. In the final representation, each i and j will have a marked weight. This value shows the strength of direct or opposite relationship of causality among the two factors and the amount in the final matrix in row i and column j.

4 Findings

The primary step was to identify the risks of supply chain quality management in food industry. By reviewing the theoretical literature and experimental work, the risks were identified. Then, the content analysis approach was applied to remove the risks with low frequency. Finally, they were adjusted to be used in supply chain of food industry (Table 1).

In the next step, some processes were performed to create the fuzzy cognitive map. The initial matrix was first formed (Table 2).

Then, the fuzzified matrix of risks of supply chain in food industry was obtained. Table 3 shows the fuzzified matrix.

Following that, strength of relationships matrix should be calculated. Table 4 shows the strength of relationships matrix.

Then, according to the comments of four food industry experts, insignificant relationships among the risks were removed and the final matrix was formed (Table 5).

Then, after entering the final matrix in FCMapper, the graphs showing the risks of supply chain quality management in food industry were drawn. Figure 2 shows the fuzzy cognitive graphs of risks. In this model, if the circles are bigger, they show the centrality or in other words, effectiveness or affectability. In Fig. 2, the nodes for the following risks are bigger: ICT infrastructure, choosing supplier, social responsibility and supplier reliability. Therefore, they are regarded as the major risks in supply chain quality management in food industry.

The results of fuzzy cognitive map can be observed in Table 6. This model consists of 30 main factors and there are 210 relationships between them. All the factors have positive effectiveness and affectability.

Table 1 Risks of supply chain quality management in food industry

Risk classification	Risk type	Symbol	References
Upstream quality management	Supplier selection	C1	[12, 29–31]
	Supplier reliability	C2	[12, 29–31]
	Supplier quality audit and assessment	C3	[6, 12, 30–32]
	Information sharing by supplier	C4	[6, 29, 31]
	Supplier involvement in design	C5	[29, 31]
	Supplier capability	C6	[6, 29–31];
	ICT infrastructure	C7	[29, 31]
	Environmental risk (Natural disaster, Political instability, Economic downturns)	C8	[29, 31]
Internal quality management	SC quality leadership	C9	[5, 12, 30–33]
	strategic planning	C10	[5, 31–33]
	Process risk (Product quality, Labor strike)	C11	[1, 6, 34]
	Information quality	C12	[1, 6, 31]
	Technology changes	C13	[1, 31, 35]
	Information sharing	C14	[1, 30, 36]
	Design for quality	C15	[1, 31, 36]
	Problem solving	C16	[5, 31, 36]
	Continuous improvement and learning	C17	[5, 31, 33]
	Training for quality	C18	[5, 6, 31]
	Internal process integrated	C19	[5, 12, 30, 32, 36]
	Operational efficiency	C20	[6, 7]
	Logistics	C21	[5, 6, 35]
Downstream quality management	Customer relationship	C22	[5, 6, 12, 30, 31, 33]
	Information sharing with customer	C23	[29–31]
	Customer involvement in design	C24	[29, 31, 36]
	Customer involvement in quality	C25	[6, 29, 31]
	Delivery reliability	C26	[6, 29, 31]
	Delivering value/innovation to customer	C27	[31, 37]
	Social responsibility	C28	[6, 29, 35]
	Forecast error	C29	[29]
	Transportation issues	C30	[6, 29, 35]

Table 2 Initial matrix

Symbol	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}
C1	35	40	25	100	65	80	20	30	75	100
C2	10	20	45	35	100	80	60	50	40	70
C3	55	65	50	60	95	100	80	20	50	40
C5	80	90	55	90	80	60	45	50	80	100
C6	75	60	45	85	50	70	35	60	50	90
C7	60	55	10	90	10	30	45	65	90	60
C8	100	65	60	95	85	70	55	60	40	70
C9	50	45	70	65	100	100	65	85	55	60
C10	80	60	50	40	35	100	35	100	50	40
C11	100	80	85	100	60	95	85	95	20	50
C12	85	60	100	95	35	100	100	35	100	55
C13	100	100	10	90	60	95	95	60	95	80
C14	95	95	90	80	30	90	90	30	90	50
C15	90	90	85	100	90	85	90	90	80	90
C16	90	85	100	95	85	100	100	85	85	100
C17	85	100	95	90	90	95	95	90	100	95
C18	90	95	90	80	95	90	10	95	95	90
C19	100	10	100	35	100	10	100	35	90	80
C20	100	60	95	60	95	90	95	60	95	50
C21	95	30	90	30	90	30	10	10	90	45
C22	90	90	10	30	85	35	10	90	80	85
C23	80	85	50	35	30	60	95	85	35	100
C24	50	35	100	100	95	30	90	100	60	95
C25	100	60	95	95	90	90	80	95	100	90
C26	95	100	100	90	100	85	10	90	95	80
C27	90	95	95	100	95	100	10	10	90	50
C28	80	90	10	30	30	10	90	90	10	45
C29	50	100	80	90	30	90	30	85	50	85
C30	45	85	50	85	50	85	50	90	45	100

To put it more simply, centrality was illustrated in Fig. 3.

In Fig. 3, it is observed that ICT infrastructure, choosing supplier, social responsibility, and supplier reliability are the pivotal risks in supply chain quality management in food industry.

Table 3 Fuzzified matrix

Symbol	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}
C1	0.25	0.33	0.08	1	0.75	1	0	0.17	0.92	1
C2	0	0	0.42	0.25	1	1	0.67	0.5	0.33	0.83
C3	0.58	0.75	0.5	0.67	1	1	1	0	0.5	0.33
C4	0.58	0.67	0.42	1	1	1	0.67	1	0.58	0.5
C5	1	1	0.58	1	1	0.67	0.42	0.5	1	1
C6	0.92	0.67	0.42	1	0.5	0.83	0.25	0.67	0.5	1
C7	0.67	0.58	0	1	0	0.17	0.42	0.75	1	0.67
C8	1	0.75	0.67	1	1	0.83	0.58	0.67	0.33	0.83
C9	0.5	0.42	0.83	0.75	1	1	0.75	1	0.58	0.67
C10	1	0.67	0.5	0.33	0.25	1	0.25	1	0.5	0.33
C11	1	1	1	1	0.67	1	1	1	0	0.5
C12	1	0.67	1	1	0.25	1	1	0.25	1	0.58
C13	1	1	0	1	0.67	1	1	0.67	1	1
C14	1	1	1	1	0.17	1	1	0.17	1	0.5
C15	1	1	1	1	1	1	1	1	1	1
C16	1	1	1	1	1	1	1	1	1	1
C17	1	1	1	1	1	1	1	1	1	1
C18	1	1	1	1	1	1	0	1	1	1
C19	1	0	1	0.25	1	0	1	0.25	1	1
C20	1	0.67	1	0.67	1	1	1	0.67	1	0.5
C21	1	0.17	1	0.17	1	0.17	0	0	1	0.42
C22	1	1	0	0.17	1	0.25	0	1	1	1
C23	1	1	0.5	0.25	0.17	0.67	1	1	0.25	1
C24	0.5	0.25	1	1	1	0.17	1	1	0.67	1
C25	1	0.67	1	1	1	1	1	1	1	1
C26	1	1	1	1	1	1	0	1	1	1
C27	1	1	1	1	1	1	0	0	1	0.5
C28	1	1	0	0.17	0.17	0	1	1	0	0.42
C29	0.5	1	1	1	0.17	1	0.17	1	0.5	1
C30	0.42	1	0.5	1	0.5	1	0.5	1	0.42	1

5 Conclusion

Supply chain quality management synchronizes the interorganizational borders with customers and suppliers to meet customers' needs. The current study tried to review the literature and use experts' opinions to comprehensively identify the risks related to supply chain quality management and analyze the influence and affectability using fuzzy cognitive map (FCM). The findings identified 30 risks related to supply

Table 4 Strength of relationships matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}
C_1		0.42	0.53	0.56	0.53	0.49	0.58	0.60	0.53	0.55	0.77	0.61	0.52	0.62	0.65	0.65	0.65	0.55	0.57	0.60	0.49	0.46	0.65	0.64	0.62	0.55	0.53	0.76	0.58	0.53
C_2	0.42		0.38	0.36	0.48	0.44	0.61	0.37	0.33	0.47	0.64	0.54	0.53	0.60	0.55	0.55	0.55	0.58	0.45	0.47	0.46	0.56	0.48	0.48	0.52	0.58	0.60	0.63	0.55	0.42
C_3	0.53	0.38		0.34	0.50	0.49	0.64	0.42	0.38	0.40	0.52	0.47	0.50	0.42	0.50	0.50	0.50	0.60	0.50	0.37	0.48	0.59	0.47	0.54	0.48	0.60	0.45	0.54	0.58	0.48
C_4	0.56	0.36	0.34		0.49	0.43	0.55	0.39	0.28	0.33	0.46	0.57	0.51	0.54	0.46	0.46	0.46	0.49	0.59	0.38	0.60	0.47	0.44	0.48	0.43	0.49	0.54	0.52	0.49	0.39
C_5	0.53	0.48	0.50	0.49		0.41	0.54	0.37	0.50	0.47	0.57	0.51	0.40	0.53	0.38	0.38	0.38	0.37	0.42	0.40	0.50	0.31	0.40	0.56	0.42	0.37	0.42	0.59	0.53	0.47
C_6	0.49	0.44	0.49	0.43	0.41		0.50	0.36	0.48	0.29	0.54	0.55	0.44	0.59	0.53	0.53	0.53	0.48	0.56	0.48	0.53	0.42	0.36	0.58	0.49	0.48	0.56	0.53	0.43	0.38
C_7	0.58	0.61	0.64	0.55	0.54	0.50		0.59	0.58	0.46	0.73	0.59	0.53	0.58	0.68	0.68	0.68	0.66	0.58	0.58	0.49	0.40	0.51	0.60	0.64	0.66	0.69	0.43	0.59	0.58
C_8	0.60	0.37	0.42	0.39	0.37	0.36	0.59		0.38	0.38	0.45	0.53	0.47	0.58	0.43	0.43	0.43	0.45	0.48	0.37	0.55	0.44	0.37	0.53	0.42	0.45	0.50	0.53	0.52	0.43
C_9	0.53	0.33	0.38	0.28	0.50	0.48	0.58	0.38		0.38	0.46	0.50	0.53	0.52	0.40	0.40	0.40	0.45	0.48	0.35	0.45	0.51	0.45	0.36	0.37	0.45	0.53	0.58	0.43	0.40
C_{10}	0.55	0.47	0.40	0.33	0.47	0.29	0.46	0.38	0.38		0.47	0.44	0.48	0.48	0.48	0.48	0.48	0.43	0.62	0.40	0.52	0.43	0.30	0.59	0.45	0.43	0.48	0.38	0.35	0.35
C_{11}	0.77	0.64	0.52	0.46	0.57	0.54	0.73	0.45	0.46	0.47		0.46	0.48	0.47	0.38	0.38	0.38	0.48	0.58	0.37	0.53	0.58	0.33	0.56	0.42	0.48	0.53	0.38	0.48	0.47
C_{12}	0.61	0.54	0.47	0.57	0.51	0.55	0.59	0.53	0.50	0.44	0.46		0.46	0.29	0.43	0.43	0.43	0.53	0.41	0.29	0.37	0.62	0.44	0.60	0.39	0.53	0.44	0.55	0.54	0.59
C_{13}	0.52	0.53	0.50	0.51	0.40	0.44	0.53	0.47	0.53	0.48	0.48	0.46		0.48	0.37	0.37	0.37	0.47	0.50	0.38	0.54	0.36	0.37	0.61	0.40	0.47	0.55	0.46	0.57	0.47
C_{14}	0.62	0.60	0.42	0.54	0.53	0.59	0.58	0.58	0.52	0.48	0.47	0.29	0.48		0.42	0.42	0.42	0.52	0.47	0.33	0.39	0.61	0.42	0.66	0.45	0.52	0.40	0.51	0.52	0.58
C_{15}	0.65	0.55	0.50	0.46	0.38	0.53	0.68	0.43	0.40	0.48	0.38	0.43	0.37	0.42		0.20	0.20	0.30	0.40	0.28	0.44	0.39	0.37	0.44	0.23	0.30	0.45	0.56	0.47	0.47
C_{16}	0.65	0.55	0.50	0.46	0.38	0.53	0.68	0.43	0.40	0.48	0.38	0.43	0.37	0.42	0.20		0.20	0.30	0.40	0.28	0.44	0.39	0.37	0.44	0.23	0.30	0.45	0.56	0.47	0.47
C_{17}	0.65	0.55	0.50	0.46	0.38	0.53	0.68	0.43	0.40	0.48	0.38	0.43	0.37	0.42	0.20	0.20		0.30	0.40	0.28	0.44	0.39	0.37	0.44	0.23	0.30	0.45	0.56	0.47	0.47
C_{18}	0.55	0.58	0.60	0.49	0.37	0.48	0.66	0.45	0.45	0.43	0.48	0.53	0.47	0.52	0.30	0.30	0.30		0.50	0.38	0.44	0.29	0.47	0.54	0.33	0.20	0.35	0.66	0.40	0.47
C_{19}	0.57	0.45	0.50	0.59	0.42	0.56	0.58	0.48	0.48	0.62	0.58	0.41	0.50	0.47	0.40	0.40	0.40	0.50		0.35	0.16	0.44	0.50	0.33	0.37	0.50	0.50	0.56	0.67	0.67
C_{20}	0.60	0.47	0.37	0.38	0.40	0.48	0.58	0.37	0.35	0.40	0.37	0.29	0.38	0.33	0.28	0.28	0.28	0.38	0.35		0.29	0.48	0.45	0.46	0.25	0.38	0.37	0.54	0.55	0.55
C_{21}	0.49	0.46	0.48	0.60	0.50	0.53	0.49	0.55	0.45	0.52	0.53	0.37	0.54	0.39	0.44	0.44	0.44	0.44	0.16	0.29		0.38	0.64	0.47	0.51	0.44	0.29	0.62	0.64	0.71
C_{22}	0.46	0.56	0.59	0.47	0.31	0.42	0.40	0.44	0.51	0.43	0.58	0.62	0.36	0.61	0.39	0.39	0.39	0.29	0.44	0.48	0.38		0.39	0.48	0.43	0.29	0.44	0.40	0.49	0.46
C_{23}	0.65	0.48	0.47	0.44	0.40	0.36	0.51	0.37	0.45	0.30	0.33	0.44	0.37	0.42	0.37	0.37	0.37	0.47	0.50	0.45	0.64	0.39		0.48	0.40	0.47	0.62	0.24	0.37	0.32
C_{24}	0.64	0.48	0.54	0.48	0.56	0.58	0.60	0.53	0.36	0.59	0.56	0.60	0.61	0.66	0.44	0.44	0.44	0.54	0.33	0.46	0.47	0.48	0.48		0.41	0.54	0.69	0.57	0.54	0.54
C_{25}	0.62	0.52	0.48	0.43	0.42	0.49	0.64	0.42	0.37	0.45	0.42	0.39	0.40	0.45	0.23	0.23	0.23	0.33	0.37	0.25	0.51	0.43	0.40	0.41		0.33	0.48	0.59	0.50	0.50
C_{26}	0.55	0.58	0.60	0.49	0.37	0.48	0.66	0.45	0.45	0.43	0.48	0.53	0.47	0.52	0.30	0.30	0.30	0.20	0.50	0.38	0.44	0.29	0.47	0.54	0.33		0.35	0.66	0.40	0.47
C_{27}	0.53	0.60	0.45	0.54	0.42	0.56	0.69	0.50	0.53	0.48	0.53	0.44	0.55	0.40	0.45	0.45	0.45	0.35	0.50	0.37	0.29	0.44	0.62	0.69	0.48	0.35		0.71	0.55	0.62
C_{28}	0.76	0.63	0.54	0.52	0.59	0.53	0.43	0.53	0.58	0.38	0.38	0.55	0.46	0.51	0.56	0.56	0.56	0.66	0.56	0.54	0.62	0.40	0.24	0.57	0.59	0.66	0.71		0.56	0.51
C_{29}	0.58	0.55	0.58	0.49	0.53	0.43	0.59	0.52	0.43	0.35	0.48	0.54	0.57	0.52	0.47	0.47	0.47	0.40	0.67	0.55	0.64	0.49	0.37	0.54	0.50	0.40	0.55	0.56		0.33
C_{30}	0.53	0.42	0.48	0.39	0.47	0.38	0.58	0.43	0.40	0.35	0.47	0.59	0.47	0.58	0.47	0.47	0.47	0.47	0.67	0.55	0.71	0.46	0.32	0.54	0.50	0.47	0.62	0.51	0.33	

Table 5 Final matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}
C_1	0.00	0.00	0.00	0.56	0.00	0.00	0.58	0.60	0.00	0.55	0.77	0.61	0.00	0.62	0.65	0.65	0.65	0.55	0.57	0.60	0.00	0.00	0.65	0.64	0.62	0.55	0.00	0.76	0.58	0.00
C_2	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.64	0.00	0.00	0.60	0.55	0.55	0.55	0.58	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.58	0.60	0.63	0.55	0.00
C_3	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.60	0.00	0.00	0.58	0.00
C_4	0.56	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.59	0.00	0.00
C_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.59	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.56	0.00	0.00
C_7	0.58	0.61	0.64	0.55	0.00	0.00	0.00	0.59	0.58	0.00	0.73	0.59	0.00	0.58	0.68	0.68	0.68	0.66	0.58	0.58	0.00	0.00	0.00	0.60	0.64	0.66	0.69	0.00	0.59	0.58
C_8	0.60	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_9	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00
C_{10}	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00
C_{11}	0.77	0.64	0.00	0.00	0.57	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.58	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00
C_{12}	0.61	0.00	0.00	0.57	0.00	0.55	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.60	0.00	0.00	0.00	0.55	0.00	0.59
C_{13}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.55	0.00	0.57	0.00
C_{14}	0.62	0.60	0.00	0.00	0.00	0.59	0.58	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.58
C_{15}	0.65	0.55	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00
C_{16}	0.65	0.55	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00
C_{17}	0.65	0.55	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00
C_{18}	0.55	0.58	0.60	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00
C_{19}	0.57	0.00	0.00	0.59	0.00	0.56	0.58	0.00	0.00	0.62	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.67	0.67
C_{20}	0.60	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.55
C_{21}	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.62	0.64	0.71
C_{22}	0.00	0.56	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.62	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_{23}	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00
C_{24}	0.64	0.00	0.00	0.00	0.56	0.58	0.60	0.00	0.00	0.59	0.56	0.60	0.61	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.57	0.00	0.00
C_{25}	0.62	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00
C_{26}	0.55	0.58	0.60	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00
C_{27}	0.00	0.60	0.00	0.00	0.00	0.56	0.69	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.69	0.00	0.00	0.00	0.71	0.55	0.62
C_{28}	0.76	0.63	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.55	0.00	0.56	0.56	0.56	0.66	0.56	0.00	0.62	0.00	0.00	0.57	0.59	0.66	0.71	0.00	0.56	0.00
C_{29}	0.58	0.55	0.58	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.67	0.55	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.56	0.00
C_{30}	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.59	0.00	0.58	0.00	0.00	0.00	0.00	0.67	0.55	0.71	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00

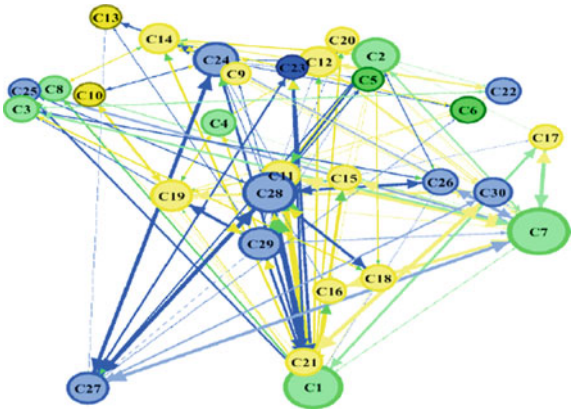

Fig. 2 FCM for risks of supply chain quality management in food industry

chain quality management in three categories, namely upstream quality management, internal quality management and downstream quality management. The analysis showed that ICT infrastructure, choosing supplier, social responsibility, and supplier reliability are the pivotal risks in supply chain quality management in food industry. Due to the variety of risks throughout the supply chain and the different effects they might have, it is important to identify and analyze the risks in terms of effects they have on the managers' decisions in the competitive conditions and provide solutions to eliminate or reduce the risks.

It is suggested that upcoming studies make use of FMEA approach to determine the intensity, incidence, and coefficient of determination of factors that contribute to failure. Using a hybrid approach, these studies will have a higher accuracy in risk analysis and provide a suitable guide to prioritize risks and evaluate effectiveness of corrective approaches to remove or mitigate risks.

Table 6 The outcomes resulting from fuzzy cognitive map approach

Concepts	Outdegree	Indegree	Centralis
C1	11.74	11.74	23.48
C2	7.00	7.00	14.00
C3	3.02	3.02	6.03
C4	2.37	2.87	5.73
C5	1.72	1.72	3.43
C6	2.84	2.84	5.68
C7	13.03	13.03	26.05
C8	2.33	2.33	4.65
C9	1.15	1.15	2.30
C10	1.76	1.76	3.52
C11	4.42	4.42	8.83
C12	4.67	4.68	9.35
C13	1.73	1.73	3.45
C14	4.82	4.82	9.63
C15	2.43	2.43	4.87
C16	2.43	2.43	4.87
C17	2.43	2.43	4.87
C18	3.05	3.05	6.10
C19	5.38	5.38	10.77
C20	2.28	2.28	4.55
C21	3.76	3.76	7.52
C22	2.95	2.95	5.90
C23	1.91	1.91	3.82
C24	6.66	6.66	13.32
C25	1.85	1.85	3.70
C26	3.05	3.05	6.10
C27	5.58	5.58	11.17
C28	9.69	9.69	19.38
C29	5.84	5.84	11.68
C30	4.29	4.29	8.58

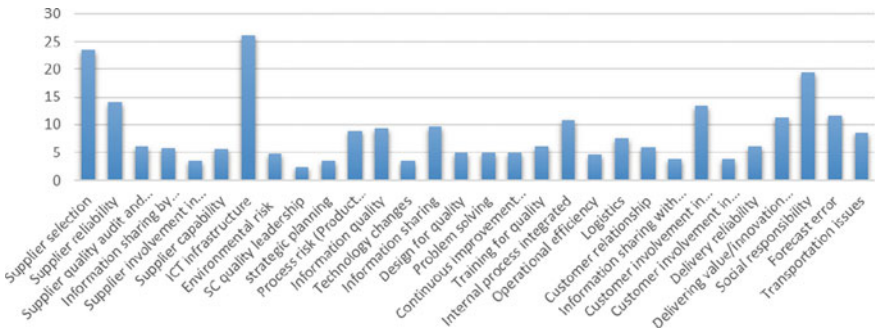

Fig. 3 Pivotal risks in supply chain quality management of food products

References

1. Quang, H.T., et al.: An extensive structural model of supply chain quality management and firm performance. Int. J. Qual. Reliab. Manage. (2016)
2. Zeng, J., Phan, C.A., Matsui, Y.: Supply chain quality management practices and performance: an empirical study. Oper. Manag. Res. **6**(1), 19–31 (2013)
3. Zu, X., Kaynak, H.: An agency theory perspective on supply chain quality management. Int. J. Oper. Prod. Manage. (2012)
4. Xu, L.D.: Information architecture for supply chain quality management. Int. J. Prod. Res. **49**(1), 183–198 (2011)
5. Talib, F., Rahman, Z., Qureshi, M.: A study of total quality management and supply chain management practices. Int. J. Product. Perform. Manage. (2011)
6. Kuei, C.-H., Madu, C.N., Lin, C.: Developing global supply chain quality management systems. Int. J. Prod. Res. **49**(15), 4457–4481 (2011)
7. Kuei, C.-H., Madu, C.N., Lin, C.: Implementing supply chain quality management. Total Qual. Manag. **19**(11), 1127–1141 (2008)
8. Ramirez-Peña, M., et al.: Achieving a sustainable shipbuilding supply chain under I4. 0 perspective. J. Clean. Prod. **244**, 118789 (2020)
9. Li, J., et al.: Blockchain for supply chain quality management: challenges and opportunities in context of open manufacturing and industrial internet of things. Int. J. Comput. Integr. Manuf. **33**(12), 1321–1355 (2020)
10. Hussain, M., et al.: Supply chain quality management and organizational performance: empirical evidence from telecom industry in the UAE. Benchmarking: Int. J. (2019)
11. Cogollo-Flórez, J.M., Correa-Espinal, A.A.: Analytical modeling of supply chain quality management coordination and integration: a literature review. Qual. Manag. J. **26**(2), 72–83 (2019)
12. Soares, A., Soltani, E., Liao, Y.Y.: The influence of supply chain quality management practices on quality performance: an empirical investigation. Supply Chain Manage. Int. J. (2017)
13. Song, H., et al.: Evaluating the effects of supply chain quality management on food firms' performance: the mediating role of food certification and reputation. Int. J. Oper. Prod. Manage. (2017)
14. Foster, S.T., Jr.: Towards an understanding of supply chain quality management. J. Oper. Manag. **26**(4), 461–467 (2008)
15. Kuei, C.H., Madu, C.N., Lin, C.: The relationship between supply chain quality management practices and organizational performance. Int. J. Qual. Reliab. Manage. (2001)
16. Lin, C., et al.: A structural equation model of supply chain quality management and organizational performance. Int. J. Prod. Econ. **96**(3), 355–365 (2005)
17. Robinson, C.J., Malhotra, M.K.: Defining the concept of supply chain quality management and its relevance to academic and industrial practice. Int. J. Prod. Econ. **96**(3), 315–337 (2005)
18. Foster Jr, S.T., Wallin, C., Ogden, J.: Towards a better understanding of supply chain quality management practices. Int. J. Prod. Res. **49**(8), 2285–2300 (2011)
19. Kaur, M., Singh, K., Singh, D.: Synergetic success factors of total quality management (TQM) and supply chain management (SCM): a literature review. Int. J. Qual. Reliab. Manage. (2019)
20. Bastas, A., Liyanage, K.: Sustainable supply chain quality management: a systematic review. J. Clean. Prod. **181**, 726–744 (2018)
21. Karamouz, S.S., Kahnali, R.A., Ghafournia, M.: Supply chain quality management performance measurement: systematic review. Int. J. Qual. Reliab. Manage. (2020)
22. Abdallah, A.B., Alfar, N.A., Alhyari, S.: The effect of supply chain quality management on supply chain performance: the indirect roles of supply chain agility and innovation. Int. J. Phys. Distrib. Logist. Manage. (2021)
23. Jahantigh, F.F., Dehghani, S.: Quality management of medical equipment hospital supply chain based on game theory. Iranian J. Supply Chain Manage. **17**(50), 68–81 (2016)
24. Ajili, M.: Prioritization of supply chain quality management components using FAHP and FDEMATEL techniques. J. Stand. Qual. Manage. **6**(3), 88–103 (2017)

25. Vasslides, J.M., Jensen, O.P.: Fuzzy cognitive mapping in support of integrated ecosystem assessments: developing a shared conceptual model among stakeholders. J. Environ. Manage. **166**, 348–356 (2016)
26. Amer, M., Daim, T.U., Jetter, A.: Technology roadmap through fuzzy cognitive map-based scenarios: the case of wind energy sector of a developing country. Technol. Anal. Strategic Manage. **28**(2), 131–155 (2016)
27. Rodriguez-Repiso, L., Setchi, R., Salmeron, J.L.: Modelling IT projects success with fuzzy cognitive maps. Expert Syst. Appl. **32**(2), 543–559 (2007)
28. Schneider, M., et al.: Automatic construction of FCMs. Fuzzy Sets Syst. **93**(2), 161–172 (1998)
29. Prakash, S., et al.: Risk analysis and mitigation for perishable food supply chain: a case of dairy industry. Benchmark. Int. J. **24**(1), 2–23 (2017)
30. Lim, A.-F., et al.: Unfolding the impact of supply chain quality management practices on sustainability performance: an artificial neural network approach. Supply Chain Manage. Int. J. (2021)
31. Phan, A.C., et al.: Impact of supply chain quality management practices on operational performance: empirical evidence from manufacturing companies in Vietnam. Supply Chain Manage. Intern. J. **24**(6), 855–871 (2019)
32. Balouei Jamkhaneh, H., Safaei Ghadikolaei, A.H.: Measuring the maturity of service supply chain process: a new framework. Int. J. Prod. Perform. Manage. **71**(1), 245–288 (2022)
33. Kaur, M., Singh, K., Singh, D.: Synergetic success factors of total quality management (TQM) and supply chain management (SCM). Intern. J. Qual. Reliab. Manage. **36**(6), 842–863 (2019)
34. Shahin, A., Balouei Jamkhaneh, H., Shahin, R.: Supply chain risk management under Covid-19: A Review and Research Agenda. In: Kryvinska, N., Greguš, M. (eds.) Developments in Information & Knowledge Management for Business Applications, vol. 4, pp. 561–580. Springer International Publishing, Cham (2022)
35. Balouei Jamkhaneh, H., Shahin, R., Tortorella, G.L.: Analysis of logistics 4.0 service quality and its sustainability enabler scenarios in emerging economy. Clean. Logist. Supply Chain **4**, 100053 (2022)
36. Parast, M.M.: A learning perspective of supply chain quality management: empirical evidence from US supply chains. Supply Chain Manage. Intern. J. (2019)
37. Sharma, M., Joshi, S.: Digital supplier selection reinforcing supply chain quality management systems to enhance firm's performance. TQM J. (2020)

Resilience of Home Health Care Providers in the Digital Era: A Scoping Review

Noura HasanPour, Hadi Balouei Jamkhaneh, and Reza Jalali

Abstract Due to the unforeseen global crises in recent years, especially COVID-19, the demand for home health care services (HHC) has increased significantly. For maintenance of the capability and function of an HHC provider in the face of unforeseen events, its resilience drivers need to be explained properly. The main purpose of this study was to investigate the resilience factors of home health care providers and the role of new digital technologies in its improvement. In this study, articles from Scopus and Web of Science were reviewed and analyzed in a scoping review given the keywords of the research. After the studied databases were screened, seventeen articles on the research topic were identified and analyzed to obtain the results of the research. The findings demonstrate that the resilience of an HHC provider consists of several dimensions, which include pre-activity, organizational culture, monitoring and evaluation, human resource empowerment, knowledge-based management, and extra-organizational contexts.

Keywords Resilience · Home HealthCare providers · HealthCare digital technology · Scoping review

1 Introduction

Particular consideration of the problems with and obstacles to health care at home, especially during epidemics, including that of the COVID-19 virus, can help improve the quality of health care. During the outbreak of the disease, most of the concern has been focused on hospital care problems, and home care services have received less attention [1]. However, use of the capacity and potentials of home health care can greatly reduce the challenges and problems associated with hospitals and help to

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modify their obligations. The issues that hospitals have been faced with during the COVID-19 crisis in the provision of medical services to patients include inadequacy of beds for patients, both COVID-19 and other patients, demand for services beyond treatment capacity, care of COVID-19 and other patients in common environments, allocation of almost all departments to COVID-19 patients and neglection of others, patients' and their families' dissatisfaction with the quality of service, and medical staff's mental disturbance and fatigue. Most importantly, there is the possibility of virus transmission and infection of other people in the environment of the health provider, which can result in a new crisis in turn, as many people have been reported to have been infected in a hospital during their patients' discharge, reception of medication, and other medical services that are not even related to the virus. All this highlights the importance of using the capabilities of home health care services, especially during the COVID-19 outbreak.

However, the demand for home health care systems has grown significantly, not only during the COVID-19 epidemic but also over the past few decades. With the recent increase in life expectancy and population [2], it has turned into a key issue in the government health policy to care for chronic patients and the elderly. Moreover, most people experience a transition from acute to chronic illnesses as they reach old ages, and prefer to go through aging at home [3]. There are also policies focused on reduction of long-term hospital care, which increase the demand for home health care. Therefore, this issue remains a top priority for governments along with the COVID-19 crisis.

It is important to note that home care services have not been spared all the effects of the COVID-19 crisis. For utilization of the potentials of these services, it is necessary to identify the drivers of resilience in home care in the current conditions to be able to increase its flexibility and tolerance in the face of demand and unforeseen events. In order to achieve resilient health care providers, therefore, we need to adopt new approaches to provision of home health care. The main purpose of this study is to investigate and analyze the concept of resilience of a home health care provider in the new era. For this purpose, the methodology of scoping review is used, involving an analysis of articles in the Scopus and Web of Science databases. The literature on home health care providers and their resilience is first reviewed. Then, the research methodology (scoping review) is described. Finally, the research findings about the resilience of home health care providers are analyzed.

2 Theoretical and Conceptual Background

2.1 Home Healthcare Providers

The growing number of old people around the world and, on the other hand, the COVID-19 crisis, which is probably the most dominant universal crisis so far, and has affected all aspects of life around the world [4], have led to challenges in the

provision of health care services. Health care consists of several dimensions, one of the most important being home health care [1]. Home health care services include those provided at the patient's residence. In this system, the patient benefits from health services under the supervision of doctors and nurses where he lives, and the medical staff controls his treatment process with the examinations they perform on him. Home care is an alternative service provided to replace hospital services [5] that can function as a support unit in the health care system to reduce its workload [6]. Particular consideration of home health care can be effective in the improvement of the quality of health care, especially during a crisis, including that of COVID-19 [7]. Home health care provides a combination of physical, medical, psychological, and social services to the individual at home instead of having the recipient go to a hospital, nursing home, or rehabilitation center.

The terms *home health care* and *home care* are different, and can be distinguished from each other with two categories: 1. skilled care and 2. unskilled care. That is, home health care requires skilled services, whereas home care requires unskilled services [8].

Brant, Fink [6] conducted a study to assess global satisfaction with the performance of home health care nurses and the obstacles to provision of palliative care at home. The researchers collected the required data through a systematic review of the literature and cognitive interviews with 532 home health care nurses in 29 countries. The results demonstrate that nurses in developing countries have more responsibilities than those in developed and high-income countries. This indicates a lack of resources in developing countries. The findings also show that there are significant obstacles to provision of home care. These include staff shortages, budget shortages, inappropriate policies, poor access to nursing and nursing services, and declining public awareness of the provided services. The respondents identified lack of time, budget, and coverage as the primary obstacles to education.

LeGrow, Cohen [9] investigated methods of parental or others' care for children needing complex care and receiving home health care services. In this systematic review, the researchers described the experiences of parents and HHC providers of their care of children with complex medical needs at home, the effects on the family, and the relationship between parents and health care providers. The parents' main concerns in the reports received on their experiences included communication, decision-making, and conflicting behavior toward health care team members.

Patterson and Deutsch [10] investigated the impact of the physical environment on the provision of home health care. In this study, staff experiences of provision of health care to the elderly living in ordinary houses were collected through a focus group interview. This study helped to clarify the essential characteristics of the physical environment for employees who provide home health care for the elderly. It also helped to develop functionally sustainable housing to minimize injuries to patients and caregivers. The research demonstrated that the treatment staff, including specialists, nurses, physiotherapists, and home caregivers, face many problems providing home health care to the elderly. It provided new insights into the architecture of home health care, which are valuable for decision-makers, architects, and planners in their attempts to understand the consequences of aging at home. Such knowledge

is important to ensure a safe workplace for health care workers as well as standard age-appropriate housing for the elderly.

2.2 Resilience of Home Healthcare Providers

With the increasing number and diversity of unsustainable resources that put pressure on systems, resilience has been raised as a prominent issue in the discourse on global health systems. This pressure can result from economic crises, climate change, environmental disasters, disease outbreaks, migration, war, population growth, or organizational needs or a combination thereof. The issue of health system resilience has received plenty of attention in the past few years to deal with unexpected events such as the COVID-19 outbreak [11]. Resilience is often associated with use of the system capacity to respond effectively to sudden and acute external shocks. It is also increasingly effective in the attempts to counteract the daily stressors that occur in health systems. Resilience empowerment is an objective of any health system and a means of adaption to evolving organizational development, including policy reform, technology combination, resource constraints, care-giving methods, and variation [12].

Resilient health care can be defined as the ability of the health care system to regulate performance before, during, or after changes and disturbances so that it can maintain the required performance in expected and unexpected conditions. For achievement of health care resilience, therefore, it is essential to study and understand how a health care system works rather than to simply continue to focus on the major reasons for their failure [13].

Some definitions of health system resilience reflect a highly reactive capacity to absorb, survive, resist, cope, respond, adapt, improve, learn, or reorganize and reinforce after instability [14, 15]. Health system resilience is defined as the capacity of institutions, health activists, and people to become prepared to respond effectively to crises and to maintain core functions in the event of a crisis. Health care organizations often have to respond to sudden, unforeseen demands and then return to normal operating conditions as soon as possible with minimum performance decrease. Organizational resilience gives organizations the capability of meeting a wide range of such demands, and prevents further breakdowns, conflicts, and other welfare threats [16]. Hollnagel [13, 17] stated that a resilient system has four main capabilities: Monitoring (knowing what to focus on, so as not to let anything turn into a threat in the future), forecasting (knowing what to expect), being responsive (knowing what to do), and learning (knowing what has happened in past successes and failures and learning from experiences). These four capabilities are widely accepted in resilience engineering. Luzeaux [18] and Tortorella, Saurin [19] expressed a similar view, and proposed four functions for flexible systems: Avoidance (prediction capacity), resistance (absorption capacity), compatibility (reconfiguration capacity), and recovery (repair capacity). Other researchers have suggested other resilience capabilities such

as recovery from unexpected events and return to balance, strength, planning, adaptability, and attention [20]. Woods [21] and Ellis, Churruca [22] defined resilience as the capacity of a system to be stable and adaptable in response to changing conditions in order to maintain system performance and safety. Resilience in an organization involves safe behavior as a main value, along with active management and preparedness for monitoring, forecasting, being responsive, and learning. For achievement of resilience in a hospital, it is essential to consider coordination of processes, resources, and technologies concerning the aim of expected and unexpected variation management and to consider the key factors that can affect resilience, preparedness, adaptability, and capability of providing a quick response to an unexpected event [23].

The resilience of day-to-day health systems has not been forecasted through maintenance of positive adjustments in difficult, unpredictable, and challenging conditions, so that the organization grows stronger and more useful. The EHSR framework demonstrates that health systems responding to unforeseen and stressful situations are implemented through the first capability, which is a combination of leadership and routine organizational processes [24], and the second capability, which involves the strategies of absorption (continuity), adaptation (incremental change), and transformation (long-term systematic change [25]. In addition, responses are activated through a third capability, that of cognitive, behavioral, and contextual resilience of the health system, which is responsible for generation of creative responses to disorders [24]. Cognitive and behavioral capacities support each other in the solution of collective problems, and create a set of possible actions to respond to the stress, making it possible to 1.understand the environmental developments, 2. make appropriate decisions, and 3. take the required measures [26]. At the same time, contextual capacities provide the organizational conditions in which cognitive and behavioral capacities are used and combined. These capacities include knowledge, financial resources, time and human resources, social capital, power, and responsibility. Therefore, they support human communication, exposure to new experiences, experimentation, reflection, and learning, providing a key context for the emergence of resilience. Capacities also exist before stressful conditions, but they are developed through stress response processes [27]. Health care resilience is conceptualized into four categories: 1.prediction, 2. sensitization, 3.transaction, and 4.adaptation. It is defined as a set of cognitive and behavioral strategies which are applied by individuals within an organizational framework [27].

2.3 Digital Technologies in Health Care

Digital technologies have been playing an important role in health care organizations since 1990, when the term *e-health* was coined [28]. With the introduction of new generations of health care digital technologies (H4.0), the level of connectivity and automation has risen dramatically; these technologies help care for patients and

raise the efficiency of administrative processes [29]. Digital technologies are cost-effective and capable of managing large amounts of data [30]. Elevation of the level of automation and information exchange in H4.0 not only leads to better, faster, cheaper health services [31, 32], but also allows physicians, nurses, and other hospital staff to make optimal use of in-hospital and inter-hospital services [33]. Along the same lines, Thuemmler and Bai [34] mentioned the customization of patient treatment and care as a double consequence of the implementation of H4.0. In the Fourth Industrial Revolution, a combination of six H4.0 design principles was proposed: 1. interoperability, 2. virtualization, 3. decentralization, 4. real-time capability, 5. service orientation, and 6. modularity. The application of these principles has been confirmed in experimental and applied studies [35].

Aceto, Persico [28] noted that most studies present a limited perspective about the application of information technology and communication in the field of health care, and a comprehensive perspective has not been presented in this field. Despite its growing popularity, evidence in the literature on H4.0 may be perceived as coincidental, lacking academic alignment and practical orientation based on fundamental theories [29]. Such inconsistencies in H4.0 research prevent a clear understanding of the implementation processes and challenges, and lead to conceptual confusion and theoretical scattering of the issue.

3 Research Methodology

There are only a few definitions of a scoping review. A quick review of key concepts on a particular research topic to find the main sources and types of evidence available can be considered as a scoping review. Such a review, especially of a complex topic or one that has not been comprehensively reviewed before, can be implemented as a specific project [36].

At a general level, a scoping review may be conducted with the aim of quickly delineating the main sources and key concepts in a research field. It can also be carried out as an independent project, especially where the subject is complex, or has not been comprehensively reviewed before. The method adopted for identification of the literature in a scoping review should achieve extensive results, instead of being guided by a highly focused research question that leads to the search for a specific study plan (as may be the case in a systematic review).

The method of scoping review requires an identification of the entire related literature regardless of the study plan.

As the literature becomes more familiar, researchers may want to redefine search terms and do more sensitive searches in the literature. For this reason, the researcher may not initially want to impose strict restrictions on search terms, identify related studies, or select a specific one. This process is not linear, but it is iterative, and forces researchers to engage in each step in a reflective manner and, if necessary, repeat the steps to ensure that the texts are comprehensively covered [37]. In this study,

the method of scoping review was used. This new method was first introduced by Arksey and O'Malley in 2005 in a codified and framed form [37].

This pattern provides a proper method of determining the scope of a set of emerging topics. When there is insufficient evidence, the following steps are taken: 1. definition of the research question, 2. specification of the collection of articles, 3. descriptive and content analysis, and 4. proposal of a framework [38]. In step 1, the research question was defined in order to determine the scope of the study and avoid ambiguity. For this purpose, two databases, Scopus and Web of Science, were examined. In recent decades, resilience has been studied widely. However, literature evidence was scarce in the simultaneous search for resuscitation and home health care. Based on this inference, a research question was raised as follows: How is the resilience of a home health care provider explained in the new age?

In step 2, we sought to specify the collection of articles. For that purpose, we conducted a comprehensive search of two databases (Web of Science and Scopus) for the period from 2014 to May 2022. The search addressed titles, keywords, or abstracts that included the terms (*resilience*, *home health care*, and *health care*), which led to the identification of 726 articles. After repetitive articles were excluded, those with titles, abstracts, or full contents relevant to the research topic were included, and these factors were applied in the screening process, seventeen articles remained.

In steps 3 and 4, descriptive and content analyzes were made. In the former step, we numerically analyzed the contents of the articles, and the contents themselves were then analyzed in the latter step.

4 Findings

According to Fig. 1, the screening of the extracted articles shows that 18 articles were published in the 2014–2021 period concerning the HHC resilience factors, which were analyzed in this study. First, the factors pertaining to HHC resilience were identified after the context of each article was examined, and the results are shown in Table 1.

4.1 The Resilient HHC Providers

After the factors concerning HHC resilience were monitored, and the repetitive ones were eliminated, the remaining factors were classified into six categories according to Table 2: Pre-activity, organizational culture, monitoring and evaluation, human resource empowerment, knowledge-based management, and extra-organizational contexts.

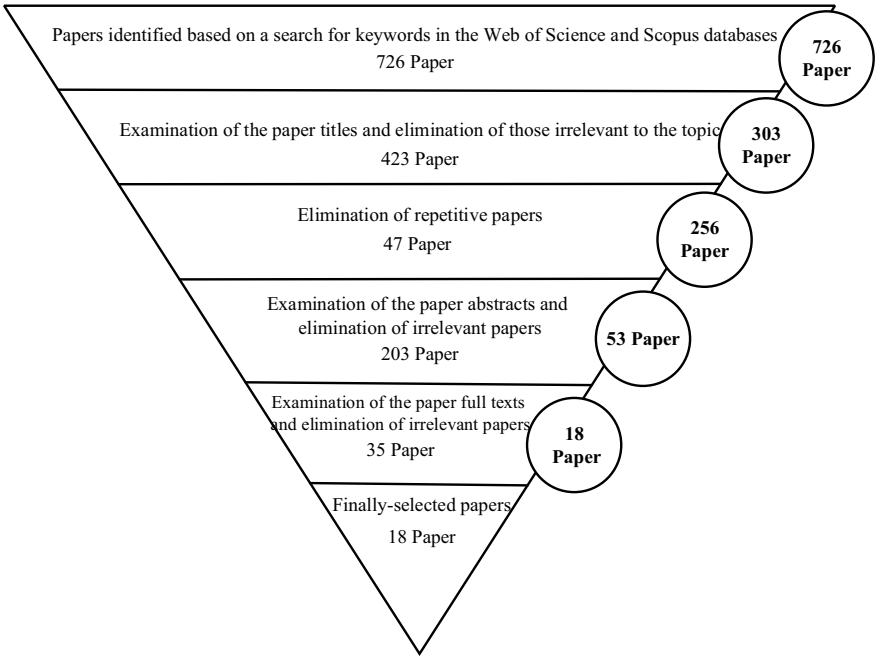

Fig. 1 Structure of the research

Table 1 Indicators concerning HHC resilience

No.	Author(s)	Paper title	Indicators of resilience
1	Hollnagel [13]	Resilience engineering and the built environment	• Responsiveness • Monitoring • Learning • Anticipation
2	Tortorella, Saurin [19]	Impacts of Healthcare 4.0 digital technologies on the resilience of hospitals	• Remote consultation and development of a plan of care in real time • Digital non-invasive care • Interconnected medical emergency support • Digital platforms for collaborative sharing • Patient data and information
3	Achour and Price [39]	Resilience strategies of healthcare facilities: Present and future	• Carbon emission • Climate change • Environmental impact • Health impact of disasters • Performance of health care facilities • Provision of energy-health transport

(continued)

Table 1 (continued)

No.	Author(s)	Paper title	Indicators of resilience
4	Carthey, de Leval [40]	Institutional resilience in healthcare systems	• Patient safety is regarded as everyone's responsibility rather than of the risk management team. • A senior manager accepts occasional, unpredicted failures as inevitable factors, forecasts them, and trains the staff how to identify and recover them. • A senior manager, whether clinical or non-clinical, is truly committed to promote patient safety, and provides sufficient resources to serve this purpose. • Safety-related issues are regularly considered at high-level meetings rather than simply after an unpleasant incident. • Past incidents are fully examined at high-level meetings, and the learned lessons are implemented as global reforms rather than local fixes. • After a number of unpleasant incidents, a senior manager's primary aim is to identify and improve defense systems that have failed rather than to seek to put the blame on certain individuals. • A senior manager adopts a proactive position with respect to patient safety, and performs some or all of the following: takes measures to identify and eliminate repetitive faults, attempts to eliminate factors in the workplace and organization that increase the probability that faults occur, and regularly verifies the health of organizational processes that contribute to unpleasant incidents by brainstorming new scenarios of failure. • A senior manager realizes that organizational factors that trigger fault (such as human resource shortage, insufficient equipment, lack of experience, imperfect training, and improper human-machine interfaces) are managed and corrected more easily than momentary psychological states, such as absence of mind, negligence, and forgetfulness. • It is comprehensible that quick management of patient safety largely depends on the collection, analysis, and dissemination of the relevant information, like any other management process.

(continued)

Table 1 (continued)

No.	Author(s)	Paper title	Indicators of resilience
			• A manager acknowledges the necessity of combining reactive outcome data (i.e. those obtained from a nearby incident reporting system) using proactive process information. The latter is far more frequent than occasional audits. This includes regular sampling of various organizational parameters (such as scheduling, rostering, protocols, defense, and training. • Meetings concerning patient safety are attended by staff from a wide range of departments and levels in the institution. • Allocation to a safety-related function (quality or risk management) is regarded as a quick track appointment rather than a dead end. Such tasks are granted appropriate statuses and wages. • It should be acknowledged that the patient's commercial aims, financial restrictions, and safety issues can be contradictory, and there are mechanisms to identify and remove these contrasts efficiently and clearly. • There are policies that encourage everyone to address patient safety issues. • The institution recognizes the crucial dependency of a safety management system on workforce trust, particularly in regard to reporting systems (A safe culture—i.e. an informed culture—results from a reporting culture, which can, in turn, originate only from a just culture). • There is a consistent policy for reporting and responding to incidents in all professional groups in the institution. • Disciplinary procedures are based on the agreed-on distinction between acceptable and unacceptable behavior. All the staff recognize that a small part of unsafe measures are actually reckless, and ensure sanctions, while the great majority of such measures should not lead to punishment (They key determinant of blame involves not the faulty measure or violation itself but the nature of the embedded behavior. Does the behavior require an unjustifiable deliberate risk or a measure that may lead to avoidable faults? In that case, the action will be guilty whether a fault or a violation.

(continued)

Table 1 (continued)

No.	Author(s)	Paper title	Indicators of resilience
			• Clinical supervisors train the young staff to practice mental and technical skills required for achievement of safe performance. Mental skills include the abilities to predict probable faults and practice proper recovery. • The institution involves channels of quick, useful, intelligible feedback to communicate the lessons learned on proactive systems of safety information. The entire institution emphasizes the generalization of these lessons rather than localization of failures and weaknesses. • The institution holds the will and resources to admit its faults, apologize, and ensure the patients (or their relatives) that the lessons learned from such unpleasant incidents will prevent their repetition
5	Hoseini Ramandi and Kashani [41]	A Framework to evaluate the resilience of hospital networks	• Accessibility • Hospital capacity • Hazard intensity • Quality of buildings • Population of the region • Number of people who died
6	Chamberland-Rowe, Chiocchio [12]	Harnessing instability as an opportunity for health system strengthening: A review of health system resilience	• Responsiveness • Sustainability • Health system prerequisites • Multi-sectoral coordination • Community engagement
7	Jolgehnejad, Kahnali [23]	Factors influencing hospital resilience	• Preparation • Responsiveness • Recovery • Staff • Infrastructure • Management • Logistics
8	Ling, Larson [42]	Beyond the crisis: Did the Ebola epidemic improve resilience of Liberia's health system?	• Awareness • Diversity • Self-regulation • Integrity • Adaption

(continued)

Table 1 (continued)

No.	Author(s)	Paper title	Indicators of resilience
9	Iflaifel, Lim [43]	Resilient Health Care: A systematic review of conceptualisations, study methods and factors that develop resilience	• Teamwork • *In-situ* practical experience • Exposure to diverse views and perspectives on the patient's conditions • Trade-offs • The value of using protocols and checklists • System design • Workarounds
10	Fridell, Edwin [44]	Health system resilience: What are we talking about? A scoping review mapping characteristics and keywords	• Leadership and governance • Medical products, vaccines, and technologies • Service delivery • Information • Workforce health • Financing
11	Pishnamazzadeh, Sepehri [45]	An assessment model for hospital resilience according to the simultaneous consideration of key performance indicators: A system dynamics approach	• Patient waiting time • Patient satisfaction • Staff burnout • Staff satisfaction
12	Jovanović, Klimek [4]	Assessing resilience of healthcare infrastructure exposed to COVID-19: Emerging risks, resilience indicators, interdependencies and international standards	• System/physical • Information/data • Organizational/business • Social/political • Cognitive/decision-making • Understand risk • Anticipate/prepare • Absorb/withstand • Respond/recover • Adapt/Transform
13	Brattheim, Faxvaag [46]	Process support for risk mitigation: A case study of variability and resilience in vascular surgery	• Capability of awareness • Capability of gaining knowledge from experience • Reduction of unintended process variation

(continued)

Table 1 (continued)

No.	Author(s)	Paper title	Indicators of resilience
14	Hollnagel, Braithwaite [47]	When disaster strikes	• Leadership (individual and shared) • Simulation and debriefings • Training • Workarounds • Proactive monitoring of signs of stress, fatigue, and anxiety • Utilization of technical capabilities • Handovers • Double-loop approach to learning • Realignment of WAI with WAD
15	Matheson, Robertson [48]	Resilience of primary healthcare professionals working in challenging environments	• Optimism • Adaptability • Initiative • Tolerance • Organizational skills • Being a team worker • Keeping within professional boundaries • Assertiveness • Humor • Sense of self-worth
16	Capolongo, Gola [49]	COVID-19 and healthcare facilities: A Decalogue of design strategies for resilient hospitals	• Design phase strategies • Strategic site location • Typology configuration for enabling disease containment • Flexibility and future-proof strategies as tools for resiliency • Functional program and access and flow management • User-centeredness and design based on inclusion and evidence • Operation phase strategies • Health care territorial network for prevention and health promotion • Patient safety and quality improvement • HVAC and indoor air quality • Innovative finishing materials and furniture • Health care digital innovation
17	Cimellaro, Malavisi [50]	Factor analysis to evaluate hospital resilience	• Cooperation and training management • Resources and equipment capability • Structural and organizational operating procedures

(continued)

Table 1 (continued)

No.	Author(s)	Paper title	Indicators of resilience
18	Bjurling-Sjöberg, Göras [51]	Resilient performance in healthcare during the COVID-19 pandemic (ResCOV): Study protocol for a multilevel grounded theory study on adaptations, working conditions, ethics and patient safety	• Influential factors and consequences for sustainable work environments • Ethical approach • Patient safety

4.1.1 Pre-activity

Organizations and health care providers seek to increase their resilience with preventive activities, known as the pre-activity approach, so that they can increase their power of exposure or speed of recovery by preparing themselves before the crisis.

4.1.2 Organizational Culture

In an HHC provider, communication between the staff, nurses, professionals, and managers and alignment with the objectives of the center provide a powerful network, functioning as a valuable asset. In this research, this included enhancement of components such as teamwork, responsibility, and self-confidence. When all the members of an organization act as one family, and remain together upon crises and troubles, it will be easier to overcome these difficulties and achieve the goals.

4.1.3 Monitoring and Evaluation

An important purpose of any service organization is to estimate and meet customer expectations. In order to ensure the achievement of this goal, an organization needs an integrated, coordinated monitoring system to trace and resolve grievances in the organization as soon as possible. The importance of these activities in critical conditions is becoming more visible.

Table 2 Classification of the indicators concerning HHC resilience

Class	Indicators
Pre-activity	• Health care territorial network for prevention and health promotion • Strategic site location • Typology configuration for enabling disease containment • Flexibility and future-proof strategies • Functional program and access and flow management • User-centeredness and design based on inclusion and evidence • Enhancement of organizational skills • Enhancement of innovative and creative workarounds • Reduction of unintended process variation • Double-loop approach to learning
Organizational culture	• Ethical approach • Enhancement of self-esteem • Humor • Sense of self-worth • Optimism • Enhancement of participation in teamwork • Enhancement of social responsibility • Instruction of the requirements and observance of professional principles in critical conditions
Monitoring and evaluation	• Patient waiting time • Patient satisfaction • Health system infrastructures • Responsibility for patients' dissatisfaction
Empowerment of human resources	• Staff adaptability • Staff innovation and creativity • Interest in teamwork • Individual and shared leadership • Capability of awareness • Capability of gaining knowledge from experience • Staff satisfaction • Maintenance of workforce health • Management of staff instruction and empowerment
Knowledge-oriented management	• Design of efficient, effective operational processes • Commitment to provide patient safety and improve service quality • Demand management and prediction • Multipartite coordination • Financial and cash flow management • Management of resources and equipment
Extra-organizational contexts	• Political stability • Avoidance of politicization in macro-decision-making in the health sector • Public support and participation • Government support in critical conditions • Adherence to the law

4.1.4 Empowerment of Human Resources

Employment of specialized, educated staff helps organizations to strengthen the main processes which are in line with resilience. Improvement of competencies and upgrades made on that basis also enhance the resilience of an HHC provider. The greater the capability and competence of an organization's manpower, the higher its capability of dealing with crises. Proper use of human capital, including performance management and staff training and development, can increase organizational agility and organizational adaptation capacity in the company and finally contribute to the resilience of the institution. A powerful management should be able to identify, attract, and maintain qualified, talented people and motivate, train, and develop them [52].

4.1.5 Knowledge-Oriented Management

The focus of the organization management on knowledge and experience can greatly contribute to the resilience of the organization. Accordingly, it is highly crucial to continuously monitor organizational errors, learn from errors, analyze the existing conditions, and obtain and access information quickly and accurately in critical conditions. In today's world, where the global economy is facing significant shocks and threats, it is important to take economic resilience into consideration to deal with the threats and to enjoy a resilient health care system. It depends on the financial capacity of a medical center how it is provided with the required budget for purchase of up-to-date equipment and other required resources, and how it provides low-cost, high-quality medical services.

4.1.6 Extra-Organizational Contexts

Extra-organizational contexts include factors that exist outside the organization, and provide the basis for its better functioning. An organization or a health care provider needs to align people, the government, and competitors with its purposes to achieve them in different conditions.

4.2 The Role of Digital Technologies in the Resilience of HHC Providers

Few studies have addressed the role of digital technologies in HHC resilience. We were motivated to investigate the issue further to consider the dynamics of the environment, unforeseen events, and the role and importance of HHC providers in the maintenance of community health and support of the hospital health care system,

particularly as most health care organizations seek to reduce cost and increase efficiency to be adapted for new social and technical demands. Studies indicate the development and implementation of digital technologies in health care organizations for faster provision of more patients' access to services [53, 54], improvement of the quality of diagnostic services [55], and reduction of the cost and efficiency of health resources [56].

Moreover, a review of the literature indicates that factors such as monitoring, forecasting, response, and learning are the four main capabilities of a resilient system [13, 17]. The H4.0 digital technology seeks to potentially enhance each of the above health resilience factors. These technologies can reduce over-reliance on human adaptive skills while offering new comprehensive opportunities for resilient performance in health care [35]. The impact of digital technologies on health care systems has been addressed in numerous studies. One of the most comprehensive investigations was made by Tortorella, Saurin [19], dividing H4.0 digital technologies into different categories, which are:

- Augmented reality as clinical decision support
- Remotely care plan development and consultation in real time
- Remotely assisted surgical and clinical procedures
- Medical devices' traceability system
- Computer assisted design of customized and modular medical devices
- Digital non-invasive care
- Interconnected medical emergency support
- Digital platforms for collaborative sharing

An example of the application of fourth-generation technologies in the health system involves electronic health records. This program provides real-time monitoring of the health of the citizens of a country. In Healthcare 4.0, a large number of wearable devices, such as smart watches, health trackers, Google smart glasses, electrocardiographs, and respirators, are used by patients to measure health-related parameters, such as heart rate and blood pressure [57]. Therefore, patients should set their mobile devices with WDs to monitor their health in real time. WDs are wireless devices that connect to cloud server using an Internet connection. These records are stored on the cloud server to allow access only of authorized users, such as hospital staff, caregivers, and medical and government agencies, for further analysis. This allows doctors and medical staff to access patient data recorded in the program. Doctors can receive notifications about their MDs from patient WDs that can be used during a patient diagnosis, and the relevant diagnosis report can be stored in a database repository located on the cloud server. Then, the patient can access these diagnostic reports with intelligent electronic tools. In an emergency, the notice can be sent to the emergency contacts on the patient's cell phone to call an ambulance for immediate care. The EHR of a patient takes biometric inputs from the biometric pattern of MDs, and stores them on a cloud server [58].

5 Conclusion

In this study, we tried to examine the resilience of HHC providers in the digital age and the role of new technologies in improvement of their resilience. The resilience of a home health care provider (HHC) is the ability of the center to survive and become prepared for anticipated conditions or crises and to recover quickly and maintain optimal performance during or after a crisis.

The results of the present study demonstrate that the resilience of an HHC provider consists of several dimensions, which include pre-activity, organizational culture, monitoring and evaluation, human resource empowerment, knowledge-based management, and extra-organizational contexts. Given that no research has been conducted so far to explain the concept of resilience of HHC providers, it is suggested that future research in the field be performed more carefully using other qualitative methodologies, such as the foundation data theory. The impact of each of the H4.0 digital technologies on the resilience of HHC providers is another challenge that can be addressed in future research.

References

1. Keywanlu Shahrestanki, S.: Challenges of home care during the Covid epidemic 19. Iran. J. Nurs. **33**(127): p. 1-6, (2020)
2. WHO, national policy on health technology. (2019)
3. Barati, A., et al.: Perspectives of experts and policy makers of the Iranian health system on the benefits of developing home health care in Iran. Hakim Health Syst. Res. **13**(2), 71–79 (2010)
4. Jovanović, A., et al.: Assessing resilience of healthcare infrastructure exposed to COVID-19: emerging risks, resilience indicators, interdependencies and international standards. Environ. Syst. Decis. **40**(2), 252–286 (2020)
5. Nikpour, B., AeenParast, A., Faraji, F.: Home care. Teb Va Tazkiye J. **1**(48), 39–42 (2002)
6. Brant, J.M., et al.: Global survey of the roles, satisfaction, and barriers of home health care nurses on the provision of palliative care. J. Palliat. Med. **22**(8), 945–960 (2019)
7. Raoofi, A., et al.: COVID-19 pandemic and comparative health policy learning in Iran. Arch. Iran. Med. (AIM). **23**(4), (2020)
8. Emily Prieto, M.: Home health care provider: A guide to essential skills. Springer Publ. Co. (2008)
9. LeGrow, K., Cohen, E., Espin, S.: Relational aspects of parent and home health care provider care practices for children with complex care needs receiving health care services in the home: a narrative review. Academic Pediatrics, (2021)
10. Patterson, M., Deutsch, E.S.: Safety-I, Safety-II and resilience engineering. Curr. Probl. Pediatr. Adolesc. Health Care **45**(12), 382–389 (2015)
11. Turenne, C.P., et al.: Conceptual analysis of health systems resilience: a scoping review. Soc. Sci. Med. **232**, 168–180 (2019)
12. Chamberland-Rowe, C., Chiocchio, F., Bourgeault, I.L.: Harnessing instability as an opportunity for health system strengthening: a review of health system resilience. In healthcare management forum. SAGE Publications Sage CA: Los Angeles, CA (2019)
13. Hollnagel, E.: Resilience engineering and the built environment. Build. Res. & Inf. **42**(2), 221–228 (2014)
14. Campbell, J., et al.: Improving the resilience and workforce of health systems for women's, children's, and adolescents' health. Bmj, **351,** (2015)

15. Kruk, M.E., et al.: What is a resilient health system? Lessons from Ebola. The Lancet **385**(9980), 1910–1912 (2015)
16. Braithwaite, J., Hollnagel, E., Hunte, G.S.: Working across boundaries: resilient health care, Volume 5. CRC Press, (2019)
17. Hollnagel, E.: Safety-II in practice: developing the resilience potentials. Routledge, (2017)
18. Luzeaux, D., Engineering large—scale complex systems. Large scale complex systems and systems of systems engineering: case studies, p. 1–84 (2013)
19. Tortorella, G.L., et al.: Impacts of Healthcare 4.0 digital technologies on the resilience of hospitals. Technol. Forecast. Soc. Chang. **166**, p. 120666, (2021)
20. Lay, E.: Practices for noticing and dealing with the critical. A case study from maintenance of power plants, in Resilience Engineering in Practice. CRC Press. p. 87–100, (2017)
21. Woods, D.D.: Four concepts for resilience and the implications for the future of resilience engineering. Reliab. Eng. Syst. Saf. **141**, 5–9 (2015)
22. Ellis, L.A., et al.: Patterns of resilience: a scoping review and bibliometric analysis of resilient health care. Saf. Sci. **118**, 241–257 (2019)
23. Jolgehnejad, A.K., Kahnali, R.A., Heyrani, A.: Factors influencing hospital resilience. Disaster Med. Public Health Prep. **15**(5), 661–668 (2021)
24. Lengnick-Hall, C.A., Beck, T.E., Lengnick-Hall, M.L.: Developing a capacity for organizational resilience through strategic human resource management. Hum. Resour. Manag. Rev. **21**(3): p. 243-255 (2011)
25. Béné, C., et al.: Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes. IDS Working Papers, **2012**(405): p. 1–61, (2012)
26. Gilson, L., et al.: Organizational change and everyday health system resilience: lessons from Cape Town. S. Afr. Soc. Sci. & Med. **266**, 113407 (2020)
27. Berg, S.H., Aase, K.: Resilient characteristics as described in empirical studies on health care. In: Exploring Resilience, pp. 79–87. Springer, Cham (2019)
28. Aceto, G., Persico, V., Pescapé, A.: The role of Information and Communication Technologies in healthcare: taxonomies, perspectives, and challenges. J. Netw. Comput. Appl. **107**, 125–154 (2018)
29. Yang, J.-J., et al.: Emerging information technologies for enhanced healthcare. Comput. Ind. **69**, 3–11 (2015)
30. González, L.P., et al.: Fog computing architectures for healthcare: Wireless performance and semantic opportunities. J. Inf., Commun. Ethics Soc, (2016)
31. Alders, M.D.L.: A reflective process for analysing organisational resilience to improve the quality of care. King's College London (2019)
32. Niemelä, R., et al.: The change of pediatric surgery practice due to the emergence of connected health technologies. Technol. Forecast. Soc. Chang. **146**, 352–365 (2019)
33. Alloghani, M., et al.: Healthcare services innovations based on the state of the art technology trend industry 4.0. In: 2018 11th International Conference on Developments in eSystems Engineering (DeSE). IEEE, (2018)
34. Thuemmler, C., Bai, C.: Health 4.0: Application of industry 4.0 design principles in future asthma management, in Health 4.0: How virtualization and big data are revolutionizing healthcare, Springer. p. 23–37 (2017)
35. Tortorella, G.L., et al.: Healthcare 4.0: trends, challenges and research directions. Prod. Plan. & Control. **31**(15): p. 1245–1260 (2020)
36. Rezaeian, M.: An introduction to scoping review. J. Rafsanjan Univ. Med. Sci. **17**(4), 291–292 (2018)
37. Arksey, H., O'Malley, L.: Scoping studies: towards a methodological framework. Int. J. Soc. Res. Methodol. **8**(1), 19–32 (2005)
38. Alemsan N. et al.: Lean and resilience in the healthcare supply chain–a scoping review. Int. J. Lean Six Sigma, (2022)
39. Achour, N., Price, A.D.: Resilience strategies of healthcare facilities: present and future. Int. J. Disaster Resil. Built Environ. (2010)

40. Carthey, J., de Leval, M., Reason, J.: Institutional resilience in healthcare systems. BMJ Qual. Saf. **10**(1), 29–32 (2001)
41. Hoseini Ramandi, S., Kashani, H.: A framework to evaluate the resilience of hospital networks. In Creative Construction Conference 2018. Budapest University of Technology and Economics, (2018)
42. Ling EJ, et al.: Beyond the crisis: did the Ebola epidemic improve resilience of Liberia's health system? Health Policy and Planning, **32**(suppl_3): p. iii40-iii47, (2017)
43. Iflaifel, M., et al.: Resilient health care: a systematic review of conceptualisations, study methods and factors that develop resilience. BMC Health Serv. Res. **20**(1), 1–21 (2020)
44. Fridell, M., et al.: Health system resilience: what are we talking about? A scoping review mapping characteristics and keywords. Int. J. Health Policy Manag. **9**(1), 6 (2020)
45. Pishnamazzadeh, M., Sepehri, M.M., Ostadi, B.: An assessment model for hospital resilience according to the simultaneous consideration of key performance indicators: A system dynamics approach. Perioper. Care Oper. Room Manag. **20**, 100118 (2020)
46. Brattheim, B., Faxvaag, A., Seim, A.: Process support for risk mitigation: a case study of variability and resilience in vascular surgery. BMJ Qual. Saf. **20**(8), 672–679 (2011)
47. Hollnagel, E, Braithwaite, J., Wears, R.L.: Delivering resilient health care. Routledge, (2018)
48. Matheson, C., et al.: Resilience of primary healthcare professionals working in challenging environments: a focus group study. Br. J. Gen. Pract. **66**(648), e507–e515 (2016)
49. Capolongo, S., et al.: COVID-19 and healthcare facilities: a decalogue of design strategies for resilient hospitals. Acta Bio Medica: Atenei Parmensis. **91**(9-S): p. 50, (2020)
50. Cimellaro, G., Malavisi, M., Mahin, S.: Factor analysis to evaluate hospital resilience. ASCE-ASME J. Risk Uncertain. Eng. Syst., Part A: Civ. Eng. **4**(1), 04018002 (2018)
51. Bjurling-Sjöberg, P., et al.: Resilient performance in healthcare during the COVID-19 pandemic (ResCOV): study protocol for a multilevel grounded theory study on adaptations, working conditions, ethics and patient safety. BMJ Open **11**(12), e051928 (2021)
52. ANYANWU, D.S.A.: Human capital development and organizational resilience in selected manufacturing firms in rivers state. Int. J. Nov. Res. Hum.Ity Soc. Sci. **3**(2): p. 43–50, (2016)
53. Balouei Jamkhaneh, H., et al.: A comprehensive framework for classification and selection of H4.0 digital technologies affecting healthcare processes in the grey environment. TQM J. **ahead-of-print**(ahead-of-print), (2022)
54. Gomez-Sacristan, A., Rodriguez-Hernandez, M.A., Sempere, V.: Evaluation of quality of service in smart-hospital communications. J. Med. Imaging Health Inform. **5**(8), 1864–1869 (2015)
55. Wang, Y., Kung, L., Byrd, T.A.: Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. Technol. Forecast. Soc. Chang. **126**, 3–13 (2018)
56. Bradley, R.V., et al.: The joint use of RFID and EDI: Implications for hospital performance. Prod. Oper. Manag. **27**(11), 2071–2090 (2018)
57. Vora, J., et al.: Ensuring privacy and security in e-health records. In: 2018 International Conference On Computer, Information And Telecommunication Systems (CITS). IEEE, (2018)
58. Hathaliya, J.J., et al.: Securing electronics healthcare records in healthcare 4.0: A biometric-based approach. Comput. & Electr. Eng. **76**, p. 398–410, (2019)

Management Information System of the Critical Path of Construction Projects by Way of Example Berlin Brandenburg Airport (BER)

Oliver Haas and Peter Markovič

Abstract Applicable and well-integrated management information system is mandatory for any construction project and any business challenge carried out in the world [1–4]. But when it comes to specific project such as the Berlin Brandenburg Airport (BER) in Germany management information system becomes one of substantial driver for proper and accurate of on-time information or, as it happens, for an informational total-failure. The disaster and mishappens of BER can be briefly illustrated and summarized by two (2) but substantial figures: overrun of more than EUR 6.2 billion compare to the original EUR 800 Mio estimated budget in 1995 and an overall delay of additional eight (9) years compared to the original estimated six (6) years of project execution and commissioning date in 2011 (so a total design and construction duration of more than fifteen (15) years). The perception in the society and in the industry all over the world is painful: the stakeholders involved and Germany as country lost it creditability to realize megaprojects in budget and in time for years perhaps forever. Unfortunately, the BER has become a worldwide known negative icon for the execution of a German design and construction project. Moreover, as a proper management information system was not in place and thereof poorly communicated or even not managed at all, outsiders got the impression that Germany as a country and the project and construction managers all levels and different engineers involved were not able to deliver such infrastructure project in the nearer future. Without doubt the way of communication over the entire execution period of BER and the numerous shifts of the critical path of BER was a disaster [5–8]. That has massive implications for outside investors not seeing Germany as a future locations and future project endeavors within European Union. To be clear, even a perfect PMIS in place could not have prevented all of the shifts on the critical path of the BER but could have prevented the late reveal and therefore the surprising

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respectively sudden and last-minute character of fundamental news and changes of the BER [6]. The aim of this study is to identify and assess management information system and its aspect as severe element to affect the critical path and finally the completion date of a design and construction project such as BER [9]. In addition, it is important to understand how does a robust and an accurate management information system support those goals. The research covers scientific journals and literature worldwide available and illustrated by correlation data analysis, both qualitative and quantitative. The findings from this study will support to understand how important an effective business and project management information system is [10–13]. The outcome of this paper also identifies the need to undertake preventive steps to identify the critical path of design and construction projects in an early stage. This paper also reveals that an effective PMIS is crucial to remain on the critical path of a construction project and finally meet the contractual death line [14, 15] .

Keywords Management Information System · Project Management · Project Management Information System · Construction Project · Berlin Brandenburg Airport · ICT · Business Principles · Organizational Processes · Cloud Service · Building Information Modeling · Infrastructure Projects

1 Introduction

1.1 Relevance and Problem

The importance of the use of an effective communication combined with the use of an adequate PMIS throughout the period of a construction project, e.g., BER cannot be emphasized enough. A proper and well-integrated PMIS and an effective communication is the spline of every design and construction project in particular as the BER project were under political leadership and influence from the very beginning. The way of communication to the society has particular weigh to gain or loose acceptance by the opponent politicians, investors, the contractors and finally the by national and international public. In particular negative effects on the critical path of BER requires a professional and a sensitive systemic of communication at the same time. Such communications skills cannot derive in short time. It requires time and patience to gain technical knowledge of infrastructure projects and the vision and understanding of the impact of appropriate or inappropriate communication to its audience (the receivers of information) for all levels. In order to run a successful communication, e.g., for BER, the sender of the relevant information, for example a shift of the critical path shall have the view in mind what happen to the receiver if the cause and effect is not explained respectively not understood. Even more irritating for the audience (the receivers of information) is the fact if such fundamental changes on the critical path comes (very) late respectively in a last-minute situation. Fundamental information can be complicate and complex in its nature if well explained but when that information coming late or in surprising way it has an additional negative leverage

to the audience (the receivers of information). If the sender repeats that more often it automatically leads into the loss of trust and confidence for the sender of such information. That happened throughout the entire execution period of BER. Hence, the distance between the sender and receiver of such information, e.g., delays and shifts of the critical path of BER continuously increased. Without doubt large-scale construction projects like BER is a complex endeavor for all stakeholders involved. But it is not a rocket science to understand that the efforts of a proper communication management require time for the involves associated to number of stakeholders and communication channels based on following formula:

$$\text{No of Communication Channels} = \frac{\text{No of stakeholders} \times (\text{No of stakeholders} - 1)}{2}$$

In other words, the number of potential stakeholders involved is multiplied with itself after subtraction of one (1) and subsequently divided by two (2). The formula finds its origin in the PMI© methodology (Project Management Institut©). This type of analysis is a tool and technique of the "Plan Communications Management" process of PMBOK© (Project Management Body of Knowledge©) and PMI©. In a (hypothetical) project consisting of one (1) stakeholder zero (0) communication channel exist, a team of two (2) stakeholders has exactly one communication channel (e.g., two (2) stakeholders). For a group of three (3) stakeholders, it would be three (3) channels as each stakeholder could talk to any of the other two (2) stakeholder. The number of communication channels increases significantly in larger stakeholder set up. For the large-scale infrastructure project BER considering approximately seventy (70) subcontractors we can assume approximately between one hundred (100) and one hundred fifty (150) has already four thousand nine hundred fifty (4950) and eleven thousand one hundred seventy-five (11,175) possible main respectively 1st level communication channels. If we would consider 2nd level communication channel than the numbers would significantly larger.

Presented as a diagram, it shows an acceleration of the curves increase:

This factual sounds trivial, but it is not by far. Considering the volume of potential communication channels of the BER it is understandable that the stakeholders underestimated the efforts for a proper communication and the need of a professional PMIS. The term "Death-by-Data" describes most best the situation the stakeholders were in during the entire project period of BER. In addition, poor communication is a common problem in particular in the construction industry as the primary skills lies in construction and not in communication.

Further, a fundamental element of a construction projects worldwide is the time to deliver the project itself by a specific date. With time in global it is meant the duration of individual or numerous activities in sequence and/or one specific date to hand over or to bring the project into a stage where an owner, client or the society can take over or use the project for his purposes. In order to ensure the take over or the acceptance of a project all of endless construction activities had to be delivered. Those deliverables are associated and in conjunction of accurate and specific information delivered at the same moment. If such information is lately delivered or not delivered at all,

effects of lately delivered information causes delays and/or disruption. Although delay and disruption matters, and time of extension of construction projects are widely discussed with professionals, experts and finally are subjects to litigation and court proceedings, missing information as root cause is mostly left out as a potential delaying or disruptive element throughout a construction project. [16–18] Looking on the lifecycle of any kind of projects PMIS is consistent required in any of the key aspects of project management process groups[1] such as (i) Initiating, (ii) Planning, (iii) Executing, (iv) Monitoring and Controlling, and (v) Closing. Even in very early stages of projects accurate and in-time delivered information and there PMIS is required and crucial. If not set out in proper manner it causes delays and disruption and therefor effects the critical path of the project. According to MacLeamy 2004 the first few steps in a lifetime of a project (beginning of the project) are crucial for the success to deliver the project in time, in quality and in budget. In other words, once the start or set up of a project being messed up or wrongly launched inclusive project relevant information were not correctly or even not available at all the chance to heal or cure or correct those failures over time are limited or even impossible [12, 19, 20] .

The figure illustrates four (4) views on the relationship of design effort/effect respectively cost on the Y axis in contrast of design stages and construction respectively execution time on the X axis. The red line or No. 1 represents the teams decreasing ability to affect project variables such as cost, schedule, and functional capability as the project progresses. The green line or No. 2 shows how the cost of making changes dramatically increase as the project progresses. The blue line or No. 3 represents the distribution of design effort in a traditional building project, when design information is developed most substantially in the construction document phase. The black line or No. 4 suggests a new distribution of design effort under a full collaboration model, where substantial information is collected, integrated, and documented earlier in the design process due in part to the input and collaboration of all stakeholders. The red line or No. 1 depicts the critical concept of earliest possible decision-making to maximize the ability to effect change and minimize the potential cost of design changes (particularly those caused by mis-integration of design information). Above being the case, it is logical that those criticalities come together and is associated with proper, accurate and solid information delivered to the stakeholder they need such information in time. Hence, project and management information all kind are being part of the critical path of any project.

1.2 The Critical Path (CP)

Understanding of the CP and alterations of the CP are essential and the only objective way to determine if a delay or disruption event really occurred to the construction project and its schedule and ultimately led to contractual and legal consequences.

[1] The big five (5) Project Management Groups are characterized by certain procedures and plans, start and end activities and sub-tasks throughout the Project period.

The importance of the understanding of the CP led further to the understanding of the concept of Critical Path Methodology (CPM). CPM is every time applied if a delay and disruption analysis is required and/or at least one (1) party seeks to be compensated from the other parties, which denies the existing delays and disruptions events. CPM is mainly carried out by appropriate programming called Program Evaluation Review Techniques (PERT) and supported by standard software applications. Although those mechanisms are mature disciplines, experience of the professionals and experts in this field is much more crucial. Finally, the outcome of CPM is assessed by those experts and the input data are interpretated differently. Common sense shall be applied, but facts and evidence viewed from a different angle may produce different results. Hence, the outcome of a proper and accurate executed CPM may vary from expert to expert and from case to case. This is no surprise as it reflects life experience from other fields.

CP per definition is the longest continuous sequence of activities through the entire construction project. The CP therefore connects the Start and End Date directly. At the same time and as those sequence of activities has no individual time buffer or float left, a delay or disruption has a direct impact, mainly negative, to the completion date of a construction project. In other words, any minor or larger alteration of the CP will change the entire project in the same affect. The project permanently breathes along the CP.

Over the course of a construction project, the CP may change through the sequences of activities as well. The CP can hop on or off of different set of activities and also switch by looking at different time windows. CP is dynamic and requires constant monitoring and control for the greater good of all stakeholders of a construction project.

Figure 1 shows numerous construction activities (A–M) and a definite start and finish milestones of the hypothetical case-study project. Each of the activities comes with a definite as-planned duration (shown in the denominator of the activity ID text field). Unit of duration could hours (h), days (d), weeks (w), months (m) or any other unit specified for construction project. For the ease of this paper, we use the term "time unit".

Red arrows illustrate the planned critical path where as black arrows represents planned non-critical path activities of the hypothetical case-study project. Those non-critical activities lying beside the critical path activities (Fig. 2).

Based on the programme of the hypothetical case-study project the total project duration is twenty-six (26) time units and the critical paths runs through activities with ID numbers A, B, C, E, F, J, L and N.

Translated into more familiar chart techniques and network schedule of the same hypothetical case-study project the bar chart looks like:

For the exercise of this paper, we insert now any delay and disruption element occurred during the execution of BER and name it with activity ID "O" and an assumed duration of three (3) time units. The new bar chart of the hypothetical case study looks like:

Figure 3 shows the new programme of the hypothetical case study delayed and disrupted by any delay and disruption element occurred during the execution of BER

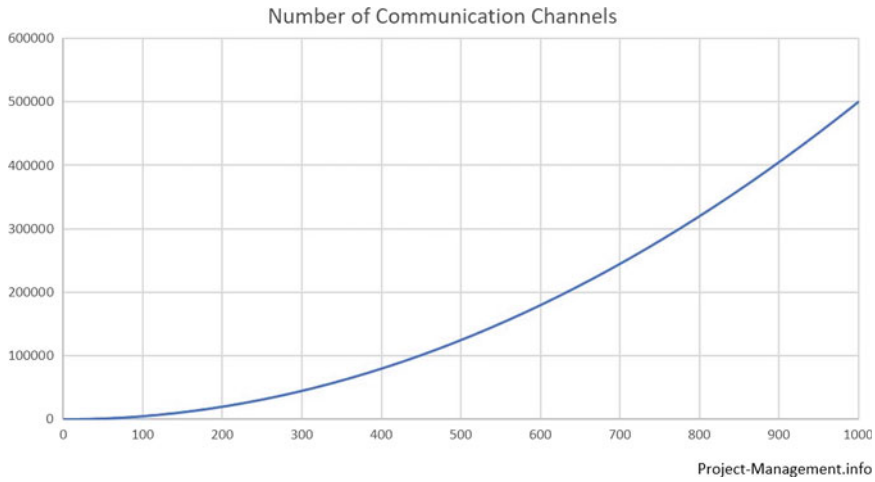

Fig. 1 Curve of the increase in the number of communication channels (y-axis) depending on the number of people involved (x-axis). *Source* https://project-management.info

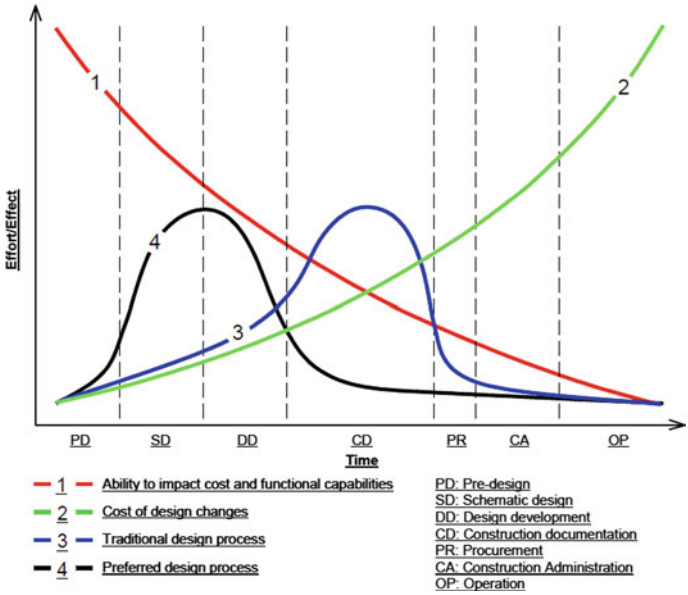

Fig. 2 Overview of design effort/effect respectively cost (Y axis) versus project time (X axis), *Source* MacLeamy 2004

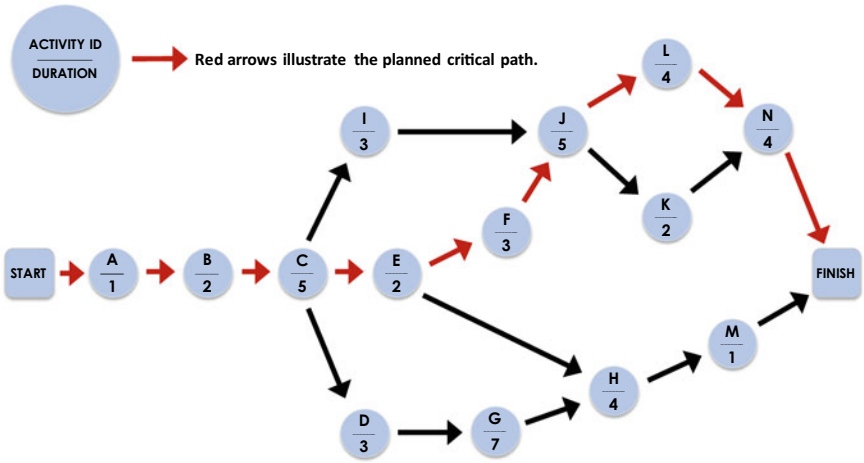

Fig. 3 Arrow Diagram of the as-planned Critical Path of the case-study project

with activity ID "O" and its related duration of additional three (3) time units. The total project duration is now twenty-nine (29) days and the critical paths runs through activities with ID numbers A, B, C, E, F, J, 0, back on J, L and N. Hence, the delay and disruption element activity ID "O" associated with a potential recovery shifted the as-planned completion date of additional three (3) time units. The non-critical activities lying beside the critical path activities are not yet affected by the delay and disruption element occurred during the execution of the BER of activity ID "O" and its recovery measures (Figs. 4 and 5).

As the effect of any delay and disruption element occurred during the execution of BER and its recovery measures hit the entire planning and construction activities and its programme. Hence, the outcome of the research questions raised in this paper is relevant for all stakeholders involved in an infrastructure project.

1.3 The Research Question (Simplified)

There are a large number of reasons why BER failed under Management (Business) Information Systems view (considering hardware, software, data, people, process). However, and based on the authors experiences and skills the following research questions can be categorized as follows:

1. What impact had the recent Management (Business) Information Systems on the critical path and overrun of the budget respectively costs of the BER?
2. Which effect were caused by the insufficient respectively not existing Management (Business) Information Systems to the critical path and overrun of the budget respectively costs of the BER?

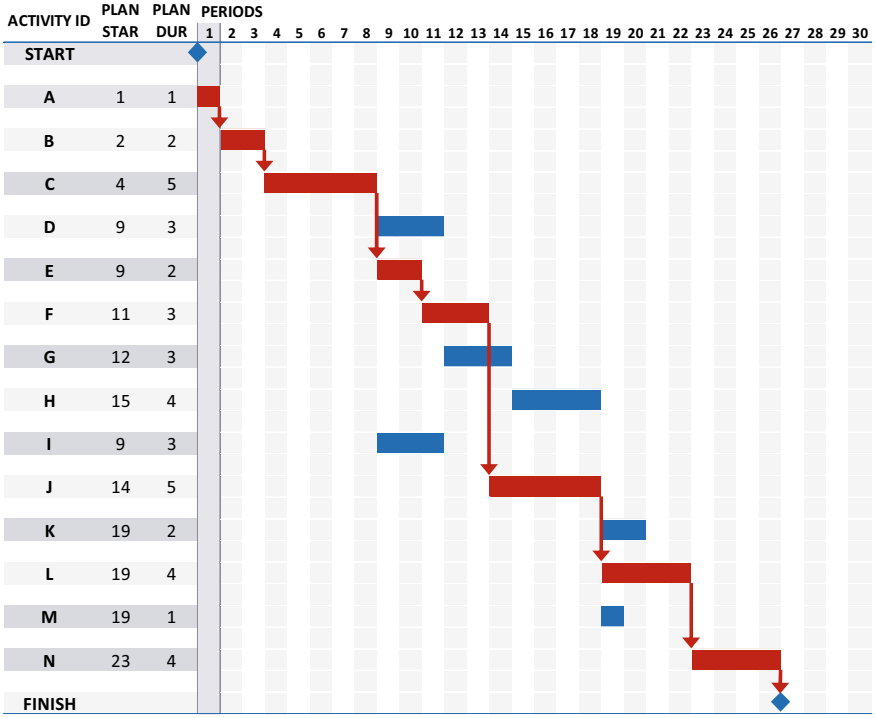

Fig. 4 Bar Chart of the as-planned Critical Path of the case study project

3. To which extent supported the recent Management (Business) Information Systems further delays on the critical path and overrun of the budget respectively costs of the BER?
4. What future business and political challenges with focus on the critical path and overrun of the budget respectively costs shall be learnt out of the outcomes of recent Management (Business) Information Systems used for BER?
5. What implications on the critical path and overrun of the budget respectively costs of the BER does this Lessons Learnt for upcoming large-scale projects worldwide?

One the one hand, aforementioned research questions are wide enough to frame the particular problems in regard of Management (Business) Information Systems associated with the happenings throughout the project period of BER in a detail manner. On the other hand, those research questions still give room to move on and research deeper in the same matter if needed.

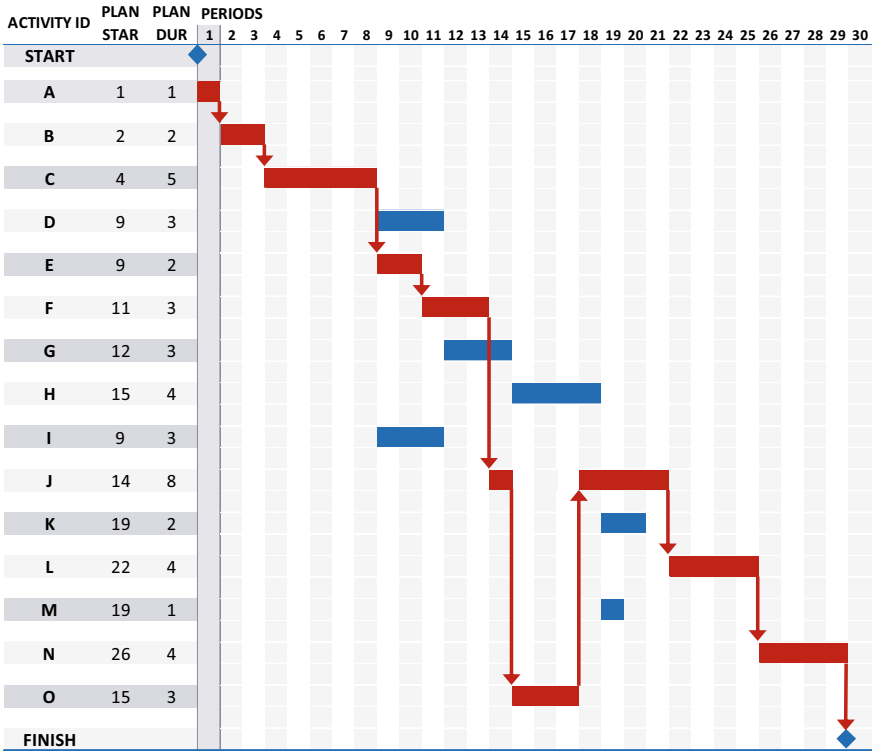

Fig. 5 Bar Chart with a sudden delay effect (activity ID "O") of the case study project

2 Research Methodology

2.1 The Applicable Research Methodology

The applicable research methodology for this paper systematically identifies the existing scientific journals and publications as well monographies and websites to a certain extent, collect, assess and qualify the data by investigation the content and quantify the results with recent analysis methods.

In addition, in the construction business and project management discipline effectiveness is a major driver of the success of the project. This effectiveness comes along with experience of the individuals involved. The method used in this paper suits and supports substantial answers to the aforementioned research questions raised. It is a standard and mature methodology in construction business and therefore does not need further justification or forensic proof. The criteria set out in this paper validate the scientific approach and produce a reliable conclusion within this research.

Finally, it can be confirmed that mature and established procedures and technologies were used for this type of research. Although different research methodology

was looked at, the use of this research methodology was properly chosen as its best suits for this industry and discipline field.

Also, research obstacles were encountered and found. Majority of objective data from the inside of the project management team or stakeholder involved. This is understandable as numerous civil and criminal lawsuits are ongoing and verdicts are pending as no party or stakeholder has to accuse himself ("nemo tenetur principle").[2] It is in the nature of the topic that such data is not completely covered and available.

2.2 Literature Review

The research of relevant literature was carried out by search words-oriented analysis in different databases and scientific research areas and catalogues available, such as (the order is unprioritized):

1. Society of Construction Law
2. Springer Link
3. Microsoft Academic
4. Academia
5. Scopus (Elsevier)
6. Google
7. Google Books
8. Google Scholar

Monographies and/or books for the research of this paper were available and used. However, focus was given on the scientific peer-to-peer publications and journals published and accurately registered. Nevertheless, for the research of this paper unlisted reports and papers were read and considered for the conclusion. The outcomes produce fifty-eight (58) of scientific and non-scientific papers, monographies or websites relevant for the research questions which are listed under references. The search words used to find papers for this research were:

1. Management Information System (MIS) in Projects, BER and/or Berlin Brandenburg Airport
2. Critical Path and/or Kritischer Weg, BER and/or Berlin Brandenburg Airport
3. Management (Business) Information Systems, BER and/or Berlin Brandenburg Airport
4. Project Management Information System, Project, BER and/or Berlin Brandenburg Airport

In addition, the literature review undertook also an assessment of the protocols of the two (2) parliamentary hearings between 27.09.2012–14.01.2021 and 28.06.2018–03.07.2021. The 1st parliamentary hearing conducted total sixty-four

[2] The Latin phrase *"nemo tenetur seipsum accusare"* is the basis of our rights against self-incrimination and forced inculpation. No one has to accuse himself.

(64) meetings with total seventy-one (71) witness statement and contained one thousand two hundred sixty-nine (1269) pages. The 2nd parliamentary hearing conducted total forty-three (43) meetings with total sixty (60) witness statement and contained nine hundred five (905) pages. These protocols were a valuable unique source of factual as they demonstrate also the bias of complex operation over time. The numerous witnesses with different backgrounds and involvement over time had different perception of what was happening to the critical path and what specific event had exactly which specific effect on their or the overall critical path. Further, the people respectively the companies for which the people deliver their design, construction activities or any for the project required information had mostly no deeper knowledge of the interface they had to work on and, if not delivered in time and in viable performance, what effect their "deviation" or "omission" had to the others party critical path or even on the overall critical path of the project. In addition, the testimonies of the witnesses demonstrate that people forget. People forget what exactly which detail information (design, scope, progress etc.) was delivered at which time exactly and what was the effect on other people work. "Who writes stays" is more than a blunt phrase. It expresses a substantial element and concept of an important project management tool to control and monitor the critical path. One of the problems is, who can judge and assess, if that what was written, is accurate and objective.

2.3 Qualitative Data

Existing fifty (50) scientific and non-scientific papers found were thematically analyzed and a qualitative assessment of the content were conducted via MAXQDA© software. In particular, the meaning of search words, see below, in combination of the adjacent ± one (1) sentence close to search word were carried out. In the case of the author James V Luisi three (3) papers were extracted from his monography "Pragmatic Enterprise Architecture" and were part of the fifty (50) scientific and non-scientific papers and assessed by MAXQDA©. In case of Ken and Jane Laudon the monography was also assessed by MAXQDA©. As the scientific and non-scientific papers, monographies or websites were bilingual, English and German language, the analysis was processed over the language pair. Search terms, which contents of two (2) or more words were search as combination term, e.g., "critical path "were used a combined search term not split into the single words "critical" and "path". Case sensitivity were not considered. The search words and/or the search combination used and applied for this paper were:

1. Poor Communication
2. Project Information Systems
3. Project Information System
4. Project Management Information Systems
5. Project Management Information System

6. Management Information Systems
7. Management Information System
8. Kritischer Pfad
9. Kritischer Weg
10. Critical path

Coding and examination of the content to retrieve wider fields for the research questions were then set out. The way of searching was then lowered and widened by the method "adjacent ± one (1) sentence of the search word" and "entire document". By doing this the key themes were identified, which is relevant for the topic of this paper.

2.4 Quantitative Data

The assessment consisted the use of relevant search words "Poor Communication", "Project Information Systems", "Project Information System", "Project Management Information Systems", "Project Management Information System", "Management Information Systems", "Management Information System", "Kritischer Pfad", "Kritischer Weg", and "Critical path" within the fifty (50) scientific and non-scientific papers relevant for the research questions. We also distinguish respectively considers varying terms spelled with or without the letter "s", e.g., "Management Information System" vs "Management Information Systems". Before the coding and analysis, the gathered papers were prepared and accurately imported into MAXQDA© software and here analyzed and statistically reviewed. The outcome of the different and numerous statistically analyzes are graphically illustrated (Fig. 6):

Total one thousand and fifty-seven (1057) codes were set based on the search words "Poor Communication", "Project Information Systems", "Project Information System", "Project Management Information Systems", "Project Management

Codesystem	1057
Autocode - ALL: Poor Communication	47
Autocode - ALL: Project Information Systems	0
Autocode - ALL: Project Information System	2
Autocode - ALL: Project Management Information Systems	77
Autocode - ALL: Project Management Information System	177
Autocode - ALL: Management Information Systems	268
Autocode - ALL: Management Information System	454
Autocode - ALL: Kritischer Weg	5
Autocode - ALL: Kritischer Pfad	1
Autocode - ALL: Critical Path	26

Fig. 6 Overview of statistically and analysing results by use of MAXQDA© software

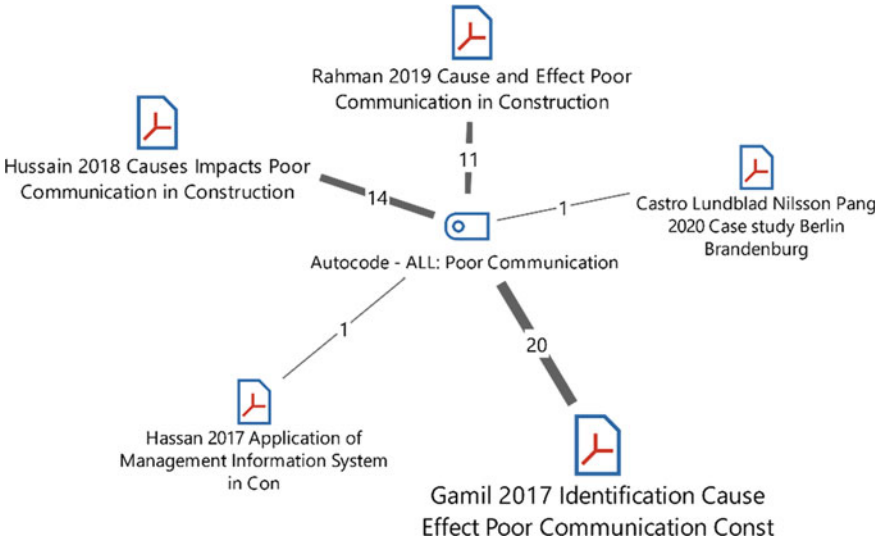

Fig. 7 Coding "Poor Communication" within 1 sentence by MAXQDA©

Information System", "Management Information Systems", "Management Information System", "Kritischer Pfad", "Kritischer Weg", and "Critical path" combined within the method "adjacent ± one (1) sentence of the search word" and "entire document" within the fifty (50) scientific and non-scientific papers. At a glance, the term "Kritischer Pfad", "Kritischer Weg", and "Critical path" is relatively rarely found (Fig. 7).

Total forty-seven (47) codes were identified and set by MAXQDA© while searched for the term "Poor Communication" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 8).

Total zero (0) codes were identified and set by MAXQDA© while searched for the term "Project Information Systems" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 9).

Total two (2) codes were identified and set by MAXQDA© while searched for the term "Project Information System" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 10).

Total seventy-seven (77) codes were identified and set by MAXQDA© while searched for the term "Project Management Information Systems" within one (1)

Fig. 8 Coding "Project Information Systems" within 1 sentence by MAXQDA©

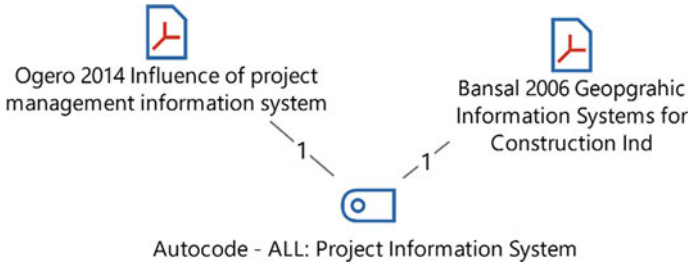

Fig. 9 Coding "Project Information System" within 1 sentence by MAXQDA©

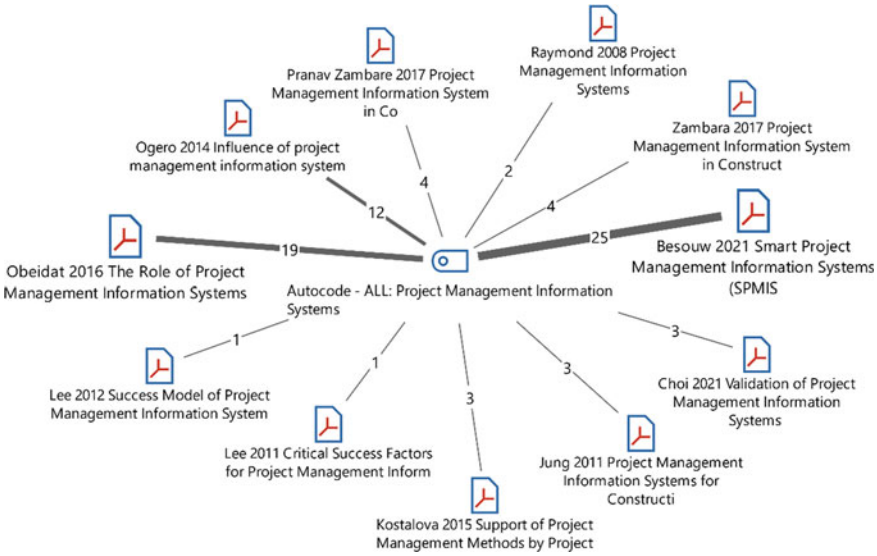

Fig. 10 Coding "Project Management Information Systems" within 1 sentence by MAXQDA©

sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 11).

Total one hundred and seventy-seven (177) codes were identified and set by MAXQDA© while searched for the term "Project Management Information System" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 12).

Total two hundred and sixty-eight (268) codes were identified and set by MAXQDA© while searched for the term "Management Information Systems" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 13).

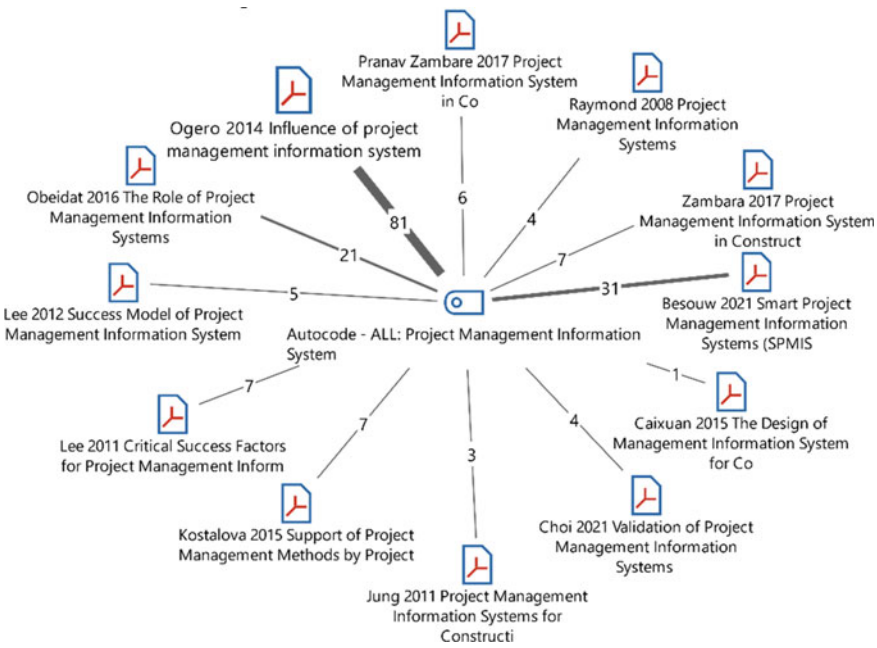

Fig. 11 Coding "Project Management Information System" within 1 sentence by MAXQDA©

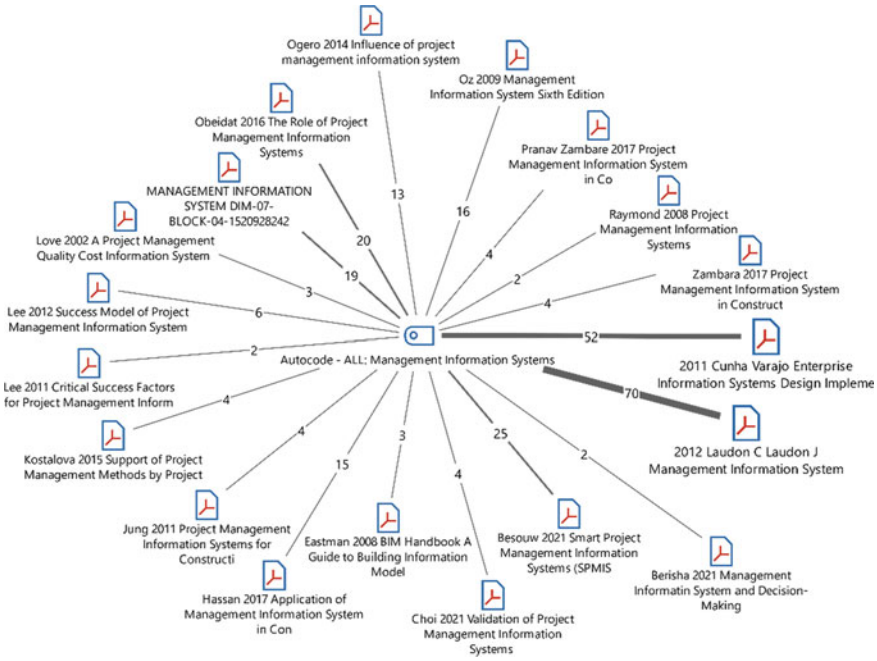

Fig. 12 Coding "Management Information Systems" within entire document by MAXQDA©

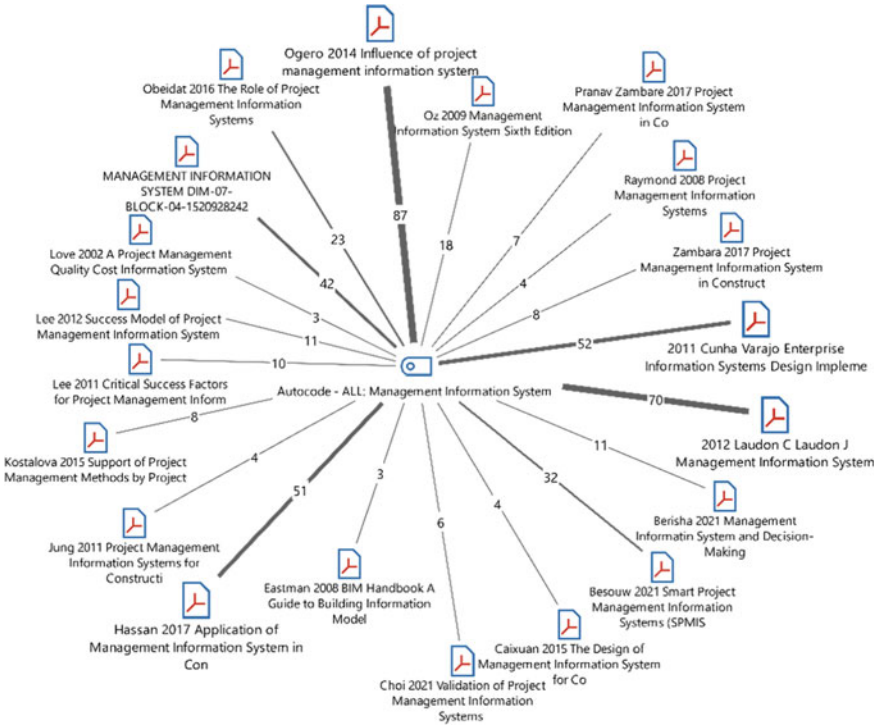

Fig. 13 Coding "Management Information System" within entire document by MAXQDA©

Total four hundred and fifty-four (454) codes were identified and set by MAXQDA© while searched for the term "Management Information System" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 14).

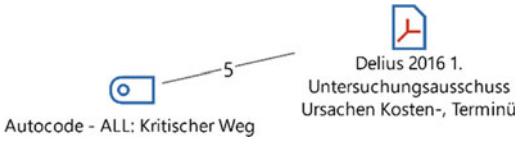

Fig. 14 Coding "Kritischer Weg" within entire document by MAXQDA©

Total five (5) codes were identified and set by MAXQDA© while searched for the term "Kritischer Weg" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 15).

Total one (1) code were identified and set by MAXQDA© while searched for the term "Kritischer Pfad" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions (Fig. 16).

Total twenty-six (26) codes were identified and set by MAXQDA© while searched for the term "Critical Path" within one (1) sentence within the fifty (50) scientific and non-scientific papers, monographies or websites relevant for the research questions.

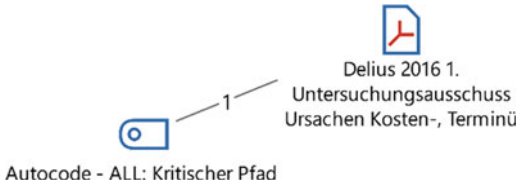

Fig. 15 Coding "Kritischer Pfad" within entire document by MAXQDA©

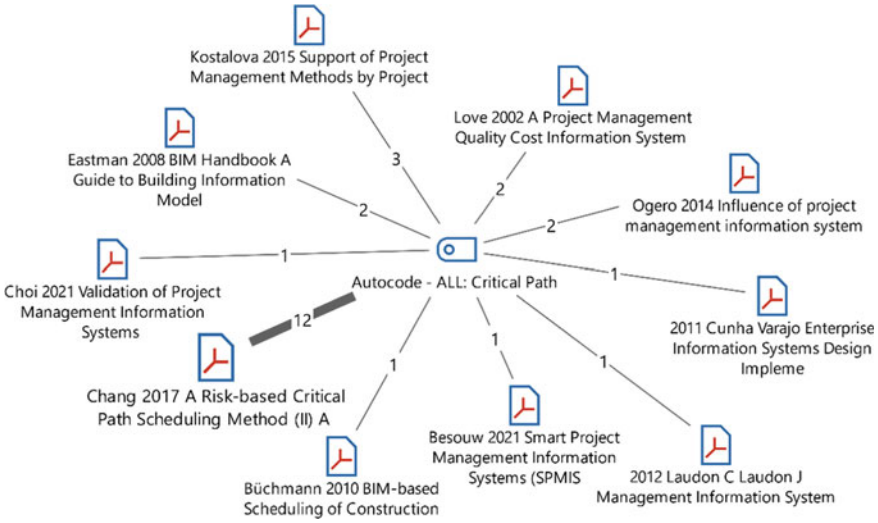

Fig. 16 Coding "Critical Path" within entire document by MAXQDA©

3 Management Information System of the Critical Path of BER

3.1 A Brief Overview of the Initial Set-Up, Ideas and Original Scope of BER

With reference to "*Project Management of the Critical Path of Construction Projects by way of example Berlin Brandenburg Airport (BER)*"[3] the history and the stakeholder landscape was painted. BER's very first ideas and activities begun in 1987 and last until official operational opening dated on 31.10.2020. Over that period of time (around twenty-three (23) years) PMIS had significantly changed in terms of what was understood by Information System but also the information technology behind it has developed massively. The original idea of which purpose a PMIS might is or should capable of, has not changed, but for sure the way and volume of hardware, software, data (input, output) and intercommunication processes significantly developed. The aim of Management Information System is to organize all people and stakeholders, the hardware and software, data, policies and procedures involved and put that information in relation to the Critical Path of BER to identify potential delays or disruption in-time. With people it is meant all professionals all levels as part of their role and responsibilities, e.g., the numerous, up to hundred fifty (150) different subcontractors for design, civil/architecture/structural works, heating, cooling, exhaust, ventilation, fire protection systems etc. serving for the BER project. With stakeholders it is meant the different but very specific instances involved in the BER project, e.g., State of Berlin, State of Brandenburg, Federal Republic of Germany, Berlin Brandenburg Flughafenholding GmbH (hereinafter "BBF"), the supervisory board of BBF, the (former) general contractor, the general designer, the numerous subcontractors etc. [7, 9, 21]

The first concept and basic designs started in in 1992 with an initial cost estimate of approximately EUR 800 Mio in 1995 with an overall design and execution duration of approximately seven (7) years. When the decision was made to kick off the BER and start execution in 2006 with an original and estimated budget of approximately EUR two (2) Billion associated with an original estimated commissioning date in 2011 none of the stakeholders involved could have imaged that they would end up with overall costs of approximately EUR seven (7) Billion (equals an overrun of additional EUR five (5) Billion), six (6) severe delays and a final commissioning date on 31.10.2020 (delays of additional nine (9) years), two hundred and forty-third (243) accidents and incidents split into four (4) fatalities, forty-six (46) major and one hundred ninety-seven (197) injuries with recorded lost time, numerous changes of key personnel in the management and supervisory board, one of the major general designer and construction subcontractor got bankrupt, several criminal and civil lawsuits started and still continued, up to approximately five hundred thousand (500.000) recorded defects, the general designer of the project was kicked out in

[3] By Oliver Haas, Peter Markovic.

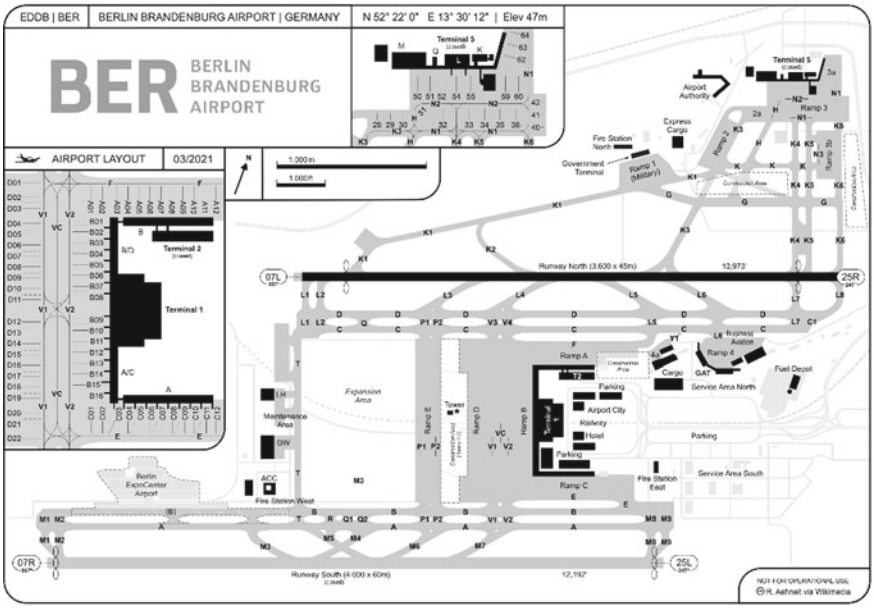

Fig. 17 Layout BER, *source* Wikipedia [22]

2012, several severe design and concept changes after the start of construction were conducted (Figs. 17 and 18).

Under the aspect of the aforementioned mishappens of BER and its effects on the critical path of the project the use of a proper PMIS becomes even more crucial. In the light of those mishappens and the below listed different shifts of the Critical Path of Berlin we investigated and assessed, if the technology, applications and the PMIS in place were able to process all the input and output data's and serve the concept of "fit for purpose" and run a Decision Support System (hereinafter "DSS") to avoid implications on the critical path of BER effectively. The key aspects were to understand whether project performance was affected, positively or negatively, by the use of PMIS in place and if the PMIS supported the collaboration and teamwork concept actively. We considered different values associated with critical path of BER, e.g., productivity, quality of information, innovation and time and speed when the project information were available for the people and stakeholders involved. Finally, we gave thoughts to the vision of that the PMIS and DSS (substantial) improved the decision making of the BER. It shall be noted the below listed different shifts of the critical paths of the BER were introduced already in "*Project Management of the Critical Path of Construction Projects by way of example Berlin Brandenburg Airport (BER)*"[4] and we relinquish to repeat the content 1:1 again [23]. We decided to concentrate on the aspects of PMIS in place or not in place and the effect to the critical path of the BER. Based on the project handbook "BBI" of BER any project related

[4] By Oliver Haas, Peter Markovic.

Fig. 18 Bird view BER, *source* Wikipedia [22]

documentation or data management in large should be processed through "ProDataS" a documentation control system. It is basically a web-based platform for any kind of data and correspondence storage and process tool. "ProDataS" was in addition to the paper-based exchange of correspondence and documentation. Although "ProDataS" was the leading PMIS for BER the two (2) parliamentary hearings in 2016 and 2020 assessed that the idea of controlling the documentation occurred failed. Main reason that the non-accuracy was that the required minimum level of available and consistent documentation was never met. The documentation was unsorted, unstructured and finally documentation was not able to find within a reasonable respectively time. Another PMIS for BER in place was "ConManS". The primary aim of "ConManS" was to logging, recording and tracking of construction management activities and matters, e.g., defects, procurement and order placements, change orders, claims, acceptances, notices of delays, notices of hindrance, notices of concerns, conditions and status inspections. The use "ConManS" shall be managed and run by the construction supervisors and construction managers. In reality, the originally purpose to use "ConManS" to manage all of the defects and track them until final completion failed respectively this PMIS was not used by the stakeholders responsible. As both PMIS, "ProDataS" and "ConManS" among other standard applications, e.g., MS software, were not used consistently and permanently the potential advantages to identify risks for delays or harms to the critical path of BER could not be employed [24–26].

3.2 Management Information System During the Shift of Critical Path of BER from 28.10.2010 to 30.10.2011

Since 2005 numerous lawsuits at Federal Administrative Court were pending, e.g., noise concerns (in regard of 55 dB(A)-threshold topic), flight routes (incoming and outgoing flights and the 15° inclination between two (2) flights), night flights permit (numbers of night flights), constantly changed numbers and the increase of passengers, planning approval procedures. As a matter of fact, above being the case the risk for un-permittable and uncertain outcomes were existing. As the final decisions of the numerous lawsuits were unknown the concept design is not even finished and therefor the basic respectively execution design should not have started. In addition, it shall be noticed that the entire approval process was not yet finished and therefore an estimated start date should not have announced beforehand. That is clear failure of a wrong PMIS in place and a failure to communicate with the stakeholders, e.g., building authority, planning approval authority and finally the public and society. Those outcomes are associated with fundamental design changes and therefor of the critical path of the design and construction of the BER.

With the bankruptcy of the MEP (mechanical, electrical, process = TGA) design contractor IGK-IGR Ingenieurgesellschaft Kruck mbH beginning of 2010 led to the impossibility to cope with already existing design delays and deficiency of the quality of the design. IGK-IGR was part of joint venture of "pgbbi" whereas this joint venture was the substantial and unique main designer for BER between 2004 and 2012. If a proper PMIS would have been in place, the changes of the scope and changes in the concept of design would have been identified and assessed and therefore could have been better communicated to the stakeholders. But it wasn't and the next provisional estimated commissioning date for BER was shifted and set to 30.10.2011 on short notice.

3.3 Management Information System During the Shift of Critical Path of BER from 30.10.2011 to 03.06.2012

Due to the implementation of new European safety standards and regulations and the need and demand for a new retail floor the entire fire safety situation for the airport changed. In addition to the existing changes of the recent and completed aforementioned lawsuits the effects on the critical path of BER are massive again. With the increase of additional requirements to the building and therefore changes to the design and interfaces to the authority itself the number of uncleared matters grows and increased steadily throughout that project stage. If a proper PMIS would have been in place the stakeholders or the instance dealing with the solely number of additional tasks and activities it could have revealed that the affects for the critical path of BER is critical and massive. In the absence of a robust implemented PMIS the responsible stakeholders were continuously flying blind in regard of the effects on the

critical path. For instance, if you do not manage and remedy the thousands of thousand activities and bring those activities to the commissioning stage before operation and functional tests ("Wirk-Prinzip-Prüfungen") in April 2012 by TÜV-Rheinland take place the project management team cannot pass those tests successfully and will fail. These leads to additional delays to the critical path of BER on top to the existing design matters not resolved yet. It is obvious the existing PMIS was not compatible and was not properly connected to the recent "ProDataS" and "ConManS" and among other standard applications of the BER project.

3.4 Management Information System During the Shift of Critical Path of BER from 03.06.2012 to 17.03.2013

Another failure of the recent PMIS was the missing interlink and information exchange (input, process, output) to one of the most critical systems in any large-scale project: the facility management and control system ("FMCS" in German language "MSR" = Mess-. Steuerungs-, und Regelungstechnik). The "FMCS" system is the central monitoring and control systems which link the mechanical and electrical completed systems with the operation and control room. In order to run the "FMCS" system all of the systems have to run smooth and flawless. The "FMCS" also reveals the dependencies and method of correct actions between the different systems. In other words, in that project stage everything in a project needs to be "fit for purpose" finally. As over time the number of defects increased and the project team struggled to implement all the running systems into the "FMCS" system in parallel, the BBF management, BBF supervisory board and their consultants became aware that with all of those remaining and open matters the delay on the critical path of the BER will not lead to the recent operation date of the BER. One of the immediate consequences was that BBF management terminate the contract with the project manager of BBF Mr. Körtgen (replaced by Mr. Amann) and the Architect (Gerkan, Marg & Partners). Again, the recent PMIS were not able to register, possess and illustrate all kind of project management matters and give the operating project team the needed output to make decision in time and in quality.

3.5 Management Information System During the Shift of Critical Path of BER from 17.03.2013 to 27.10.2013

After the change of the aforementioned operational project team an assessment of the recent construction status and design the new appointed project manager and BBF management concluded and published on 07.09.2012 led to the shift of the critical path and commissioning date to 27.10.2013 with the need of additional EUR 1.2 billion (EUR 276 million for additional cost in general construction, EUR 67 million

for construction costs due to delayed opening, EUR 230 million for compensation for operational costs due the delayed opening, EUR 322 million additional risk allowance and loss of revenue, EUR 305 million for additional cost for noise reduction measures). With those massive increase of time and budget it become obvious that the PMIS were not able run usefulness and integrated in regard of the scope, cost, time and quality management needed to manage the critical path of BER.

3.6 Management Information System During the Shift of Critical Path of BER from 27.10.2013 to Firstly Unknown Resp. March 2014

With reference to the recently published paper "*Project Management of the Critical Path of Construction Projects by way of example Berlin Brandenburg Airport (BER)*"[5] the fire safety experts assessed and stated that the flaws and deficit in the fire safety concept, fire safety design and recent fire safety construction are not accordance to the fire safety regulations and technical solutions are still not found and designed. With an PMIS in place from the very beginning, which is capable to manage risks systematically and continuously, to identify and list existing and potential risk, to analyze the impact and timely required resources to resolve such risks, to minimize the ultimate impacts out of such risks and mitigate them in a timely manner the changes of such risk over time could have in control. The outcome would have been a communication system which give qualified output to the stakeholders to make decisions rightful and in time necessary to avoid but at least minimize the effects to the critical path of the BER. Further, but use of statistical methods qualitative and quantitative analysis could have been executed and displayed. As those analysis were not conducted substantial and qualified project reviews, in particular assessment of the effects on the critical path of the BER were not able. As previously stated, the project management team were flying blind.

3.7 Management Information System During the Shift of Critical Path of BER from March 2014 to Somewhere to or Between 2016 and November 2017

The period between March 2014 until November 2017 could be described as the rough time for the critical path of the BER. Changes in the systematic of risk taking and remaining tasks assessments also affects the timeline of the BER, e.g., the culture of risk taking varied, the numbers of technical exclusions (if-when-correlations) and preventive measures (e.g., defect-free execution design available to launch activities

[5] By Oliver Haas, Peter Markovic.

and procure qualified personnel and material required) where adjusted. Mr. Mehdorn, Managing Director of the BBF, announced on 15.12.2014 that he would leave the BBF management. In addition, former managing director of company GICON (advisor and head of construction department for BBF; four-teen (14) companies with four hundred sixty (460) employees) in the period of April 2014 till Juni 2014 and technical head of BBF management since was conducted in autumn 2014 for bribery, fraud, increased invoicing and price rigging for one (1) suspended sentence and a forfeit of one hundred thousand (100.000) EUR. Further, in summer 2015 company Imtech got bankrupt, but was also convicted earlier of fraud and violation against compliance law as they manipulated and increase hours sheets and invoiced services, which were never installed or conducted earlier. All those effects in parallel to the running project and on top of the existing unresolved design matters in regard of the fire safety systems led to increase of the remaining tasks to complete the BER. In the absence of the proper PMIS the huge number of the recent risks to the critical path of the BER an effective control to come back on track were not possible. As the end and operational date of BER consistently were shifted and delayed, the reputation over time and for the project management team felt to an all-time low.

3.8 Management Information System During the Shift of Critical Path of BER from January 2017 to 31.10.2020

With reference to the recently published paper "*Project Management of the Critical Path of Construction Projects by way of example Berlin Brandenburg Airport (BER)*"[6] the recent BBF management was laid off again and Mr. Daldrup took over as new CEO BBF management on 07.03.2017. The team around Mr. Daldrup made a few changes also in regard of an PMIS to identify and run a critical path method and link time schedule matters to technical testing expert and instances ("TÜV"), and integrate recent defects in design and on site. In addition, the new project management team established "Best-in-class" or "Best Practice" method and migrate it into the PMIS [27–29]. Further, "Lessons Learnt"-method and the use of best-case and worst-case scenarios within the remaining programme, schedule and critical path etc. was incorporated in the PMIS. The critical path and the commissioning time schedule was then evaluated and assessment by external experts to prove the robustness of its content. Although this approach and measures takes a while to see positive effects and the outcomes, the project management team brought the BER finally to operation on 31.102020. On the one hand the changes to previous PMIS are minimal as those measures are not rocket science within construction industry. On the other hand there were the path and road for the success to complete the BER and to manage the critical path of BER until the final stage.

[6] By Oliver Haas, Peter Markovic.

4 Conclusion

4.1 Summary

The outcome of this paper in regard of effects of proper or improper PMIS in place on specific or the overall critical path of large-scale infrastructure and construction project of BER doesn't surprise at all [30–32]. This paper reveals that the PMIS is a data-driven and an important processing element to run and manage complex infrastructure projects and its critical path successfully. This paper examines the need of PMIS from the very beginning and if not implemented the negative outcome for all stakeholders involved [5, 33, 34] . The research of this paper also reveals if a proper PMIS is absence the impact on the critical path is massive and not recoverable over the execution time of the project [35]. Although PMIS creates costs for implementation, maintenance and running the costs for a state-of-the-art PMIS is definitely an advantage and a pay-off for a project. This paper also gives answers to the question raised under provisions 1.3.1 of the same paper [36]. This papers also produced a qualified summary and conclusion to use PMIS, in particular for large-scale projects as follows:

1. Apart from the main elements of an integrated PMIS (hardware, software, data, process, people) the main key element to gain positive effect from PMIS is the fully integration of all those main elements in one framework but controlled by experienced professionals throughout the execution period of the project [37–39]. Significantly volume of data will be issued and produced, processed by soft- and hardware and finally assessed and further used by people to make the right decisions for the project [10, 13, 40, 41]. Those decisions will have in the one or the other way effects to the critical path of the project. "Death-by-data" shall be avoided and the pure volume of data is not the major driver to run the project. Small, but focused information used for project specific activities will add business value in addition. The more PMIS is an integrated systems which covers costs, time, risks, scheduling, resource, documentation, authority etc. the more gain can be expected from an PMIS [5]. The PMIS used in BER is a good example not to run a PMIS. It was not integrated, not run by professional and over time (1987 till 2020) not adjusted and properly maintained.
2. Effective and integrated PMIS is a project within the project, but will help over time to manage the critical path of large-scale and long-lasting project [25, 42, 43]. The correct implementation and budget to build up a PMIS requires an understanding of the advantages over time to use a PMIS and the difference to start making data-driven decisions and finally data-driven innovation. In other words, a robust PMIS requires a PMIS-sponsor within the organization and the acceptance of the people running such PMIS to support the needs of the project and the support and understand the risks on and close to the critical path [21, 44, 45].
3. The main reason to fail throughout the execution period of a project in regard of PMIS are the "usual suspects" why PMIS respectively projects run in disaster or

shift the critical path: poor communication, late communication and late information submission, wrong information at the wrong time or wrong information at the right time, missing team work once the information is available, misinterpretation of the information, late response to an information, conflict between construction parties, poor documentation of a certain information, unclear communication channels with effect to other project stages, lack of effective communication rate, slow information flow between stakeholders [46, 47].

4.2 Further Research and Limitation

With reference to "*Project Management of the Critical Path of Construction Projects by way of example Berlin Brandenburg Airport (BER)*"[7] the history and the stakeholder landscape was painted. In addition, and as previously mentioned, numerous civil and criminal lawsuits are in process and awaiting verdicts or settlements in regard of compensation of damages, bribery, bankruptcy, theft/burglary, inflated invoices and concealment etc. occurred throughout the execution of the BER [48, 49]. Some of the recent conclusions are preliminary only and therefore partially limited linked to the aforementioned matters. Dependent of the outcome of those lawsuits and settlement new information and/or status will be revealed and brought up. Based on those new aspects and findings new research shall be conducted as cause and effect on the critical path can be changed due to altered outcomes. Further, during the two (2) parliamentary hearings between 27.09.2012–14.01.2021 and 28.06.2018–03.07.2021 and the finalized and recent investigations for the BER only limited stakeholders and witnesses were heard and had a change to testify. From those limited numbers of testimonies only a few were published and accessible for the non-stakeholders [49, 50]. Without doubt if more stakeholders and witnesses involved would be heard additional information relevant to costs and delay, and therefor varied and different implications on the critical path would be revealed. Cause-and-effect for the massive overrun of cost and time for the BER would be better understandable. This paper mentioned numerous extraordinary matters throughout the execution of the BER, e.g., dismissal of different BBF management staff on short notice, termination of the contract with the longtime involved main designer "The Architects" (joint venture between "Gerkan, Marg & Partner" and "JSK architekten"), insolvency of company Imtech and their new investor and buyer company R.O.M. etc.… It is in the nature of such events that all the detail implications and direct and indirect dependencies associated with such events cannot be assessed till the last factual and therefor the effects on the overall critical path or which activities jumped than on the recent critical path could not be evaluated. Such fundamental changes throughout the execution of such large-scale infrastructure project will always influence the critical path on a short and on a long term. Experiences from other large-scale project shows, that some of the changes will only have effect and will only realize after a

[7] By Oliver Haas, Peter Markovic.

long preparation and investigation period and therefor falsely associated with the wrong root cause [51–56] .

References

1. Enterprise resource planning for global economics: managerial issues and challanges. Information Science Reference, Hershey, PA (2008)
2. Abdul Rahman, I., Gamil, Y.: Assessment of cause and effect factors of poor communication in construction industry. IOP Conf. Ser. Mater. Sci. Eng. **601**, 12014 (2019). https://doi.org/10.1088/1757-899X/601/1/012014
3. AIA Document E202 TM.: International Conference on Education Technology, Management and Humanities Science (ETMHS 2015) (2008)
4. Berisha-Shaqiri, A.: Management information system and decision-making. Acad. J. Interdiscip Stud (2014). https://doi.org/10.5901/ajis.2014.v3n2p19
5. BMDV.: Reformkommission Bau von Großprojekte Endbericht (2015)
6. Castro, S., Lundblad, L., Nilsson, G., Pang, X.: Case study Berlin Brandenburg Airport (2020)
7. Delius, M.: 1. Untersuchungsausschuss Ursachen Kosten-, Terminüberschreitungen BER d17-3000 (2016)
8. Fiedler, J., Wendler, A.: Large infrastructure projects in Germany, between ambition and realities: public infrastructure project planning in Germany: the case of the BER airport in Berlin-Brandenburg (2015)
9. Kühnemann-Grunow, M.: 2. Untersuchungsausschuss Ursachen Kosten-,Terminüberschreitungen BER d18-4010 (2021)
10. Scott, D., Wah, K.M., Li, H.: Web-based construction information management systems. The Aust J Constr Econ Build **3**(1) (2007)
11. van Besouw, J.: Smart Project Management Information Systems (SPMIS) for Engineering Projects (2021)
12. Wu, C.: The design of management information system for construction project cost. In: International Conference on Education Technology, Management and Humanities Science (ETMHS 2015) (2015)
13. Zelenay, J., Balco, P., Greguš, M.: Cloud technologies—solution for secure communication and collaboration. Procedia Comput. Sci. **151**, 567–574 (2019). https://doi.org/10.1016/j.procs.2019.04.076
14. Smith, P.: Project cost management with 5D BIM. Procedia. Soc. Behav. Sci. **226**, 193–200 (2016). https://doi.org/10.1016/j.sbspro.2016.06.179
15. Solutions, L.: 10 Reasons Construction Project Management Information Systems Fail. Lydon Solutions (2015)
16. Lee, S.-K., Yu, J.-H.: Critical success factors for project management information system in construction. J. Constr. Eng. Proj. Manage. **1**, 25–30 (2011). https://doi.org/10.6106/JCEPM.2011.1.1.025
17. Love, P.E., Irani, Z.: A project management quality cost information system for the construction industry. Inf Management **40**, 649–661 (2003). https://doi.org/10.1016/S0378-7206(02)00094-0
18. Munir, M.Y., Jeffery, H.: Building Information Modelling (BIM): a summary of some UK experiences as guide to adoption in Nigeria (2013)
19. Ogero, D.K.: Influence of project management information system on project performance in the construction industry: a case of Nairobi county, Kenya (2014)
20. Schwalbe, K.: Introduction to Project Management: With a Brief Guide to Microsoft Project Professional 2016. Schwalbe Publishing, Minneapolis, MN (2017)
21. Hussain, M., Othman, A., Gabr, H., Aziz, T.: Causes and Impacts of Poor Communication in the Construction Industry (2018)

22. Wikipedia.: Bau des Flughafens Berlin Brandenburg. https://de.wikipedia.org/w/index.php?title=Bau_des_Flughafens_Berlin_Brandenburg&oldid=218126303. (2021) Accessed 6 Jan 2022. [NOTE FROM AUTHOR PICTURES ONLY FROM WIKIPEDIA]
23. Gregus, M., Kryvinska, N.: Service Orientation of Enterprises—Aspects (2015)
24. Choi, J., Ha, M.: Validation of project management information systems for industrial construction projects. J. Asian Archit. Build. Eng. 1–12. https://doi.org/10.1080/13467581.2021.1941999
25. Cruz-Cunha, M.M., Varajao, J.: Enterprise information systems design, implementation and management: organizational applications. Business Science Reference, Hershey, PA (2011)
26. Eastman, C.M.: BIM handbook: a guide to building information modeling for owners, managers, designers, engineers and contractors, 2nd edn. Wiley, Hoboken NJ (2011)
27. O'Brien, J.A., Marakas, G.M.: Management Information Systems, 10th edn. McGraw-Hill Irwin, New York (2011)
28. Odisha State Open University: Management information systems—basic concepts. In: Axelby, G. (ed.) CIM Coursebook 01/02 Management Information for Marketing Decisions, pp. 8–19. Routledge (2013)
29. Zambare, P., Dhawale, A.: Project Management Information System in Construction Industry (2017). https://doi.org/10.5281/zenodo.822964
30. Ashraft, H.: Building Information Modeling: A Framework for Collaboration. Society of Construction Law (2009)
31. Axelby, G.: CIM Coursebook 01/02 Management Information for Marketing Decisions. Routledge (2013)
32. Pal, M., Bansal, V.K.: Geographic Information Systems for Construction Industry: A Methodology to Generate 3-D View of Buildings (2006)
33. Borrmann, A., König, M., Koch, C., Beetz, J.: Building information modeling. Springer International Publishing, Cham (2018)
34. Büchmann-Slorup, R., Andersson, N.: BIM-Based scheduling of construction—a comparative analysis of prevailing and BIM-based scheduling processes. In: Proceedings of the CIB W78 2010: 27th International Conference. Cairo, Egypt, 16–18 November (2010)
35. Chang, H.K.: A Risk-based Critical Path Scheduling Method (II) a visual approach system using BIM (2017)
36. Flyvbjerg, B., Holm, M.S., Buhl, S.: Underestimating costs in public works projects: error or lie? J. Am. Plann. Assoc. **68**, 279–295 (2002). https://doi.org/10.1080/01944360208976273
37. Obeidat, M., Aldulaimi, S.: The role of project management information systems towards the project performance: the case of construction projects in United Arab Emirates. Int. Rev. Manage. Market. **6**(3) (2016)
38. Oz, E.: Management information systems, 6th ed. Thomson/Course Technology, Boston Mass (2009)
39. Raymond, L., Bergeron, F.: Project management information systems: an empirical study of their impact on project managers and project success. Int J Project Manage **26**, 213–220 (2008). https://doi.org/10.1016/j.ijproman.2007.06.002
40. Winfield, M.: Building Information Modelling: The Legal Frontier—Overcoming Legal and Contractual Obstacles (2015)
41. Zhiliang, M., Liang, Q.: Framework of Information Management System for Construction Projects (2005)
42. Fuchs, M.: Bedarfsplanung gemäß E DIN 18205, Rathaus Arnsberg – Klimaneutrales, offenes Rathaus (2017)
43. Gamil, Y., Abdul Rahman, I.: Identification of causes and effects of poor communication in construction industry: a theoretical review. Emerg. Sci. J. **1** (2018). https://doi.org/10.28991/ijse-01121
44. Hamdi, O., Leite, F.: Conflicting side of building information modeling implementation in the construction industry. J. Leg. Aff. Disput. Resolut. Eng. Constr. **6**, 3013004 (2014). https://doi.org/10.1061/(ASCE)LA.1943-4170.0000137

45. Hassan, H.A.: Application of Management Information System in Construction Projects in Sudan (2017)
46. Hurtado, K., O'Connor, P.: Contract issues in the use of construction building information modeling. Society of Construction Law (2009)
47. Ivanochko, I., Gregus, M., Urikova, O., Alieksieiev, I.: Synergy of services within SOA. Procedia Comput. Sci. **98**, 182–186 (2016). https://doi.org/10.1016/j.procs.2016.09.029
48. Jung, Y., Kim, H., Joo, M.: Project management information systems for Construction Managers (CM): current constituents and future extensions. In: 28th International Symposium on Automation and Robotics in Construction (ISARC 2011). Proceedings of the International Symposium on Automation and Robotics in Construction (IAARC), Seoul, Korea, 29.06.2011–02.07.2011
49. Kostalova, J., Tetrevova, L., Svedik, J.: Support of project management methods by project management information system. Procedia. Soc. Behav. Sci. **210**, 96–104 (2015). https://doi.org/10.1016/j.sbspro.2015.11.333
50. Kwon, S.: 28th International Symposium on Automation and Robotics in Construction (ISARC 2011). International Association for Automation and Robotics in Construction (IAARC) (2011)
51. Kryvinska, N., Gregus, M.: SOA and its business value in requirements, features, practices and methodologies (2014)
52. Laudon, K.C.: Management Information Systems: Managing the Digital Firm, 12th edn. Prentice Hall, Boston (2012)
53. Lee, S.-K., Yu, J.-H.: Success model of project management information system in construction. Autom. Constr. **25**, 82–93 (2012). https://doi.org/10.1016/j.autcon.2012.04.015
54. Luisi, J.V.: Pragmatic enterprise architecture: strategies to transform information systems in the era of big data. Morgan Kaufmann an imprint of Elsevier, Amsterdam, Boston (2014)
55. MacLeamy.: Collaboration, Integrated Information and the Project Lifecycle in Building Design, Construction and Operation (2004)
56. Miller, J.A.: The implementation of web-based project management systems by the general contractor: transferring from hard-copy to digital format (2011)

Creating Cross-Platform Application in Java and C++

Milos Sajbidor, Peter Vesely, and Michał Krajewski

Abstract By integrating the platforms of Java and C++, it was possible to provide theoretical and practical considerations related to cross-platforming and the proposed author's approach to developing applications of this type. The following work focuses on the scope of software engineering, with a particular focus on technology analysis for multi-platform applications. This scope includes creating a portable application using Java. The data is stored in relational databases, after which the use of different databases as a place to store information from prints is another point concerning the scope of work. The main goal of the work is to analyze the capabilities of selected technologies for the development of cross-platform applications, namely Java and C++. The analysis boils down to comparing the operation and the way these people work, as well as showing their advantages and disadvantages. In addition, the purpose of the work is to present how to create a portable, multi-platform form system based on the practical example. In this highly complex world, the proposed way can combine the advantages and strengths of both platforms for the benefit of users to create an innovative and sustainable environment.

1 Introduction

Nowadays, the fashion for mobile applications was created. Every user wants to have the program not only on their PC but also on their mobile phone or tablet so that they can use the app at any time without returning home specifically. This has put an additional burden on developers. Now, in order to succeed in the growing IT

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market, you can't just get stuck within a single platform when writing applications, and writing separate code for each platform is a non-efficient solution that, with a larger project, prevents it from supporting and expanding [1]. This is a situation where the concept of cross-platforming has gained enormous popularity not only in developers of software but also in the creators of operating systems.

The interest of the author of this work on this issue began when we noticed a very small number or even the absence of applications that create overflow prints and prints for cash deposits for both PCs and mobile devices. Competing applications have minimal functionality.

Applications with richer features are very expensive or are parts of larger programs, so you can't create your own prints. The following thesis shows one of the most common ways to create cross-platform applications using one of the most common, the most popular technologies, which is Java.

The following work focuses on the scope of software engineering, with a particular focus on technology analysis for multi-platform applications. This scope includes creating a portable application using Java. The data is stored in relational databases, after which the use of different databases as a place to store information from prints is another point concerning the scope of work.

The main goal of the work is to analyze the capabilities of selected technologies for the development of cross-platform applications, namely Java and C++. The analysis boils down to comparing the operation and the way these people work, as well as showing their advantages and disadvantages. In addition, the purpose of the work is to present how to create a portable, multi-platform form system based on the practical example described above. When using databases, there is an additional issue, which is to show how to use multiple databases, thanks to the use of object-relational mapping (OR M).

The practical part of the work involves the creation of two applications, generating cash deposit prints and overflow prints, which are saved in for you have PDF. It is also possible to record information about transfers in the data. One application runs on a PC with a Microsoft Windows or Linux operating system (desktop) installed, and the other works on a mobile platform with Android installed. Both use a single, main module that provides all the functionalities of both programs, including creating PDF documents or supporting databases. It can therefore easily be concluded that these programs differ only in the GUI and share the main part responsible for logic.

The following work does not address the issue of creating PDF document from scratch or creating performance tests of compared technologies.

The chapter 2 of the following thesis contains issues related to the development of cross-platform applications. It provides general theoretical considerations on this topic and compares selected technologies for cross-platform application development. In addition, this chapter proposes a proprietary approach to the development of cross-platform applications, which was used in the practical part of the work.

The chapter 3 shall contain a description of the technologies used in the practical part and the reasons for their choice.

Chapter 4 is a description of the project, which is the result of a practical part of this work, in the form of technical documentation, while Chap. 5 is a description of

the application created, which is used to generate cross-left prints and prints for cash deposits, in the form of user documentation.

2 Create Cross-Platform Applications Java and C++

Writing programs that have the ability to run on multiple platform-system or hardware match is, in a sense, a modern tech-nowhere to know not only the theoretical basics, but also the tools used to create applications of this type. The following chapter provides theoretical and practical considerations related to cross-platforming and the proposed author's approach to developing applications of this type.

2.1 Portability and Multi-platformer

Before delving into the technical aspects of this thesis, it is worth getting acquainted in general with the concepts of portability and cross-platforming generated in [1].

According to the author [1], portability is the ability to move software between platforms, that is, environments where there is a need to compile and run a program. Moving no cross-platform software requires the preparation of all the necessary elements to run a given program on a given platforms, such as, for example, a compiler or a library.

Portability is a very general term—for example, a developer of a program typically under the Microsoft Windows operating system and directly uses system libraries. After writing, compiling, and running the program, the code "is moved to another computer", which is also under the control of Microsoft Windows. There, too, it is compiled and running. According to what is written above—the code is portable, but is it possible to compile it and run it on the same device only that under the control of the Linux operating system? The answer is negative because the code does not work with this platform.

In the field of computer science, there are two types of platforms: plat—software forms, which include, among others, operating systems, and hardware platforms, which include, for example, a given sora architecture. The above sample program is portable within the same software platform and perhaps multiple hardware platforms under the control of a single operating system.

The program is called cross-platform if it is portable and works independently of the hardware and software platform on which it is urachal—name and which was defined by the developers of the software.

For example, the same application can run on a Microsoft Windows operative system, installed on a computer with an x86-familyprocessor, as well as on a Linux operating system, installed on a computer with an ARM-based processor. It is worth stipulating here that the application does not have to work on every possible platform, only on those that have been mentioned by the creator (more about this in Sect. 2.2).

When asked about the high level of interest associated with the issue of multi-platform formality, the introduction to the work was answered. It is worth reflecting on the other advantages of creating applications in such a way that they are portable and cross-platform. The author of the book [1] presents them in a very interesting society.

Portability expands the product sales market and saves costs associated with changing and implementing the system in which the product is intended to operate. Cross-platform software can be sold, for example, to users of a Microsoft Windows-based computer as well as Apple's Mac OS. However, if you change, for example, the operating system in the user, the cost of implementing the created software is negligent.

Portable software is more resistant to errors. This way of creating software forces the programmer to have the correct programming habits, so that detecting errors in the program is much simpler, even by a person not edified to the project. It is also much easier to develop such software.

Portable software has more growth opportunities. The new version of the platform provides the possibility to extend the functionality of the application running on it. When a program is only on one version of the platform, the developer has limited capabilities.

2.2 Cross-Platform in Java and C++

The rationale for choosing both languages for benchmarking is quite clear—despite their high syntax similarity [2], the principle of operation of the two identical programs written in the two above programming languages is completely different. In Java, the resulting code of the program is written in the language of the virtual machine (so-called bytecode) and is executed by the virtual bus machine [3]. The resulting code for a C++ program is native binary code that is executed directly by the compute-ra processor [1]. Both of these solutions have their advantages and disadvantages, which are described in detail below.

C++ [1] is a high-level language whose resulting code is native binary code executed directly by the com-putter processor. This gives you an advantage at run time over languages such as Java, where the procedures and orders contained in the resulting program are executed by a virtual machine, which then processes them and transmits them to the computer's processor. It's not hard to guess that such an "indirect" program results in a reduction in spending. This is precisely justified by Table 1, which compares the results of the execution time of the same programs written in different programming languages, including Java and C++.

Table 1 contains the results resulting from the implementation of the same algorithm described below and implemented in several different programming languages. For this work, the first six rows of the table are taken into account. The tests themselves are simple and compact. To be done the algorithm uses the possible functionalities of the individual language, and in particular the "higher level" data structures [4], such

Table 1 Comparison of run times (in seconds) of the same programs written in different programming languages [4]

Benchmark	Time (s)	Factor
C++ Opt	23	1.0x
C++ Dbg	197	8.6x
Java 64-bit	134	5.8x
Java 32-bit	290	12.6x
Java 32-bit GC*	106	4.6x
Java 32-bit SPEC GC	89	3.7x
Scala	82	3.6x
Scala low-level*	67	2.9x
Scala low-level GC*	58	2.5x
Go 6g	161	7.0x
Go Pro*	126	5.5x

as lists, map vectors. No concurrency and multithreading aspects or mechanisms were used to increase the capabilities of a particular language compared to others.

In order to perform the performance tests contained in Table 1, an algorithm for detecting cycles in the control graphs was impleaded in each language [4]. At the beginning, a very simple control flow graph is generated, containing 4 nodes in which the start and end nodes are connected by an edge. The detection of cycles is then run 15,000 times. Later, a much larger control flow graph is created, containing a total of 76,000 cycles, and cycle detection is started 50 times. All the languages tested use the same generator, which at first cooks a set of graphs.

Each implementation of an algorithm is as close as possible to its formal specification, and none of them contain any language-specific optimization or adaptation. The algorithms are designed to make the results as objective as possible for each variant.

As explained in [4], C++ opt means compiling C++ code with its optimization by the compiler (usually under the pro-censor on which the code is compiled), while C++ dB means compiling code with debug flags. For Java, Java 64-bit and Java 32-bit mean running the program on standard configured VMs in 64- and 32-bit versions, respectively. Java 32-bit GC means running the program on a virtual machine with optimized Garbage Collector, while Java 32-bit SPEC GC indicates a specific Garbage Collector configuration proposed by the test authors.

When analyzing the markings of individual rows in Table 1, in the case of writing a program for the average user, the sphere of interest is narrowed to the first four items.

C++ is a language that, despite its improved performance (Table 1), is less likely to be used to build cross-platform applications than Java. This is because the developer has more problems related to the portability of code written in this language across multiple platforms [1].

A program written in C++ must be compiled separately for each platform on which it must run. This forces the developer to create application-building tools for each

```
1 #ifdef _WIN32
2  Beep (440,100); /* 440 Hz , 100 ms */
3 #else
4  printf("\a"); /*use ANSI "bel" charecter */
5 #endif
```

Listing 1 Example of starting a speaker on a motherboard depending on the operating system [1]

platform, including compilers, linkers, builders, or project management tools [1]. If you are using external libraries, you must use those that are also cross-platform. If, on the other hand, there is a need to use system libraries, or if the programmer himself wants to create a biblio-cross-platform file, the code should designate a precompiler which methods to call depending, for example, on the operational system [1].

Listing 1 is an example of using methods from system libraries in cross-platform applications. If the application is compiled under the Microsoft Windows system, the Beep() method will be called from the windows.h [5]. Otherwise, the printf() method from the universal studio library [6] is called. Similarly, the Qt cross-platform library [7], written in C++ that runs independently on Microsoft Windows and Linux operating systems, works similarly.

There are far fewer problems with writing cross-platform applications in Java. As mentioned above, in this language, the program's code is written in the language of the virtual machine. The vortex machine performs it by calling the appropriate system procedures and shipping the appropriate orders to the processor. If there are no direct references to system resources in your code, the program you created should have a cross-platform echo in itself. If a Java virtual machine can be installed on a given hardware platform and operating system, the program should run in a new environment. This is the main premise of java developers. Of course, this also depends on other factors, such as the cross-platformness of external libraries used in the program.

Another important feature that differs between the two languages is memory access. In C++, you can access your computer's memory so that you can, among other things, create pointers to in-memory variables. This gives an advantage over Java, for example, when a library is created, which will be used by both programs on computers with a lot of operational memory, as well as those on mobile phones with a small amount of such memory [1]. You can then use variables in a variety of ways and erase unnecessary data from memory immediately. This feature has some consequences—it is necessary to prevent memory leaks by every time all data is stored at the end of the program or procedure in the program.

Listing 2 shows the memory leakage situation in a C++ program. The indicator reserves space in memory for the int-type replacement. At the end of the program, this space is not freed, so it will reserve for some memory is not suitable for use by any other program until the computer is restarted.

The lack of direct access to memory by the Java-based program undoubtedly has several significant advantages. The problem of memory freeing is dealt with by the internal mechanism of the virtual machine, called *garbage collector* [2]. This

```
1     int main (int argc , char * argv[])
2     {
3           int *variable = new int;
4
5     return 0;
6
```

Listing 2 Causing c++ memory leakage

```
1     public class MainClass {
2
3     public static void main(String [] args ) {
4
5           Integer variable = new Integer (0);
6
7           // block end ,
8           // automatic call  System.gc ();
9     }
10    }
```

Liting 3 Prevent java memory leakage with Garbage Collector

mechanism is called from time to time and the result is "garbage collection", that is, the removal of unnecessary data. These unnecessary data is not deleted immediately when it is no longer used in the program—it is deleted only when the execution of the garbage collector process is completed by the program or virtual machine. This makes it easier for the program to work at the expense of the program's increased instantaneous memory usage. Listing 3 presents a situation similar to listing code 2 written in C++—only an integer variable is reserved. At the end of the program execution, the **Java virtual machine** calls the *garbage collector* procedure, which frees up memory space reserved by already redundant variables in the program. There is no memory leakage.

As you can see above, in the case of C++, the programmer must take care of freeing dynamically allocated memory. If it has a pointer to a dynamically created object, it must call a delete statement at the end of the program or procedures with a pointer that points to the address of the instance [8]. This situation is illustrated by Listing 4, which by the way is solved—not a problem with Listing 2. There are no indicators in Java—there are only references. They are also found in C++ but have a slightly different and more significant role here [2].

You can find a lot of algorithms that implement "trashing you remember" in high-level languages. One of them is a very well-known and simple technique for counting references [2], which is presented in the form of a block mat in Fig. 1. It consists in the fact that each object has a reference count. When an object is assigned to a refe-unit, the counter is incremented. When, on the other hand, the reference value is null (this occurs, among other things, when the block in which the reference occurs is completed or the reference is explicitly assigned by the programmer), the counter

Listing 4 Resolution to memory leakage in language C++

```
1 int main (int argc , char * argv[])
2           {
3           int * variable = new int;
4
5           delete variable;
6
7           return 0;
8           }
```

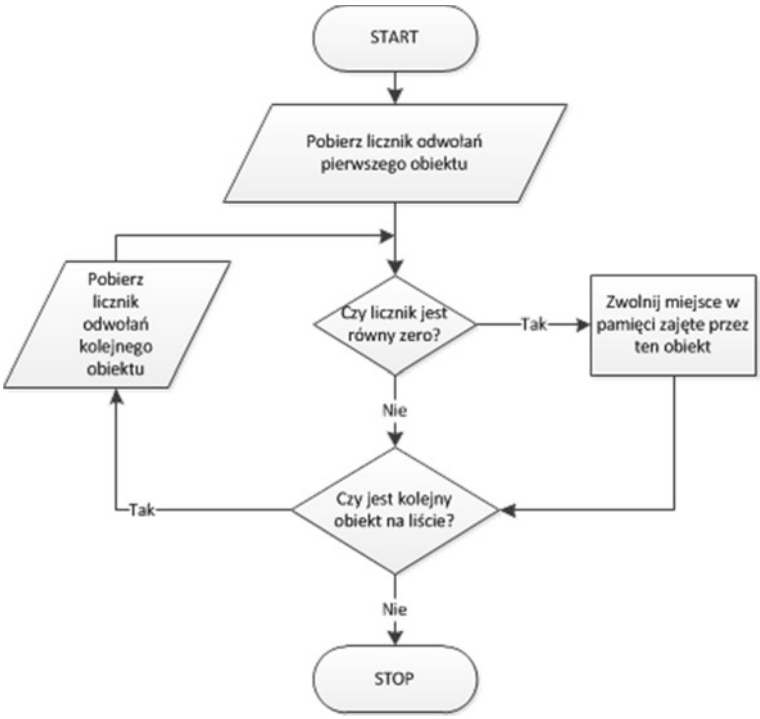

Fig. 1 Flowchart of garbage collector reference counting technique

is demented. The garbage collector checks the reference count of each object when it starts. If it finds an object with a counter of zero, it releases the corresponding area in memory.

2.3 Proposed Way to Create Cross-Platform Applications

The practical part of this work is to prove the need for cross-platform applications. It also presents one way to create such programs. The result is an application that works on both PC and mobile devices. As you know, PCs tend to have much larger displays

than mobile devices. In addition, their graphical interface varies significantly. To address these and other problems related to the portability of programs, the following is a proprietary approach to creating cross-platform applications.

2.3.1 Model-View-Controller Architecture

Model-View-Controller (MVC) is a design type that assumes a specific, functional specialization of mods in program code. It is one of the solutions that facilitates the development of software development and coordination of design work. This pattern is mainly used to organize the structure of the application, which sits on the graphical user interface and consists in separating the appearance layer from other layers of the application.

Figure 2 shows a simplified model-view-controller architecture diagram. It is easy to see what elements part of it and what connections between these elements are take place. In MVC architecture, system components are divided into three parts: Model (Mode l), View, and Controller [9].

The components contained in model are components that represent data and system logic. Components from the Controller module intercept requests, system user queries, and mapped them to calls to the response methods from the Model module, and then move the control to the View module. View components are components responsible for presenting data to the system user—they retrieve data from the Model module and then display it on the user's screen.

Figure 2 is also an example of how MVC is used as a web server architecture [9]. In a big way, the scheme of operation is as follows: the web browser, which is the most stro- not the user of the system, sends a cased request to the Module Controller (1). This parse and processes the request by calling the appropriate methods from model module (2). In the next step, the Controller module passes the dish to the View module (3). The View module retrieves the necessary data from the Model module (4) and then generates a web page that is sent to the user's web browser (5).

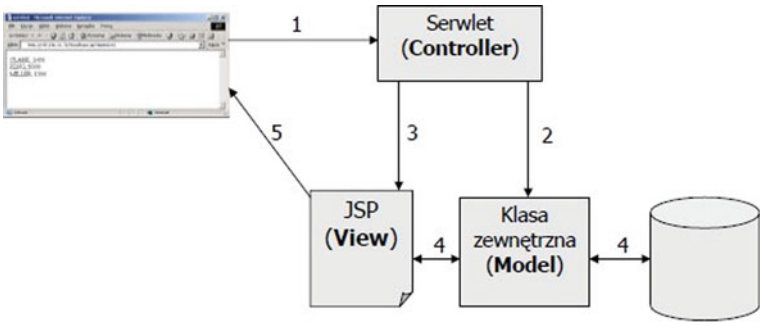

Fig. 2 MVC sample application schema [9]

Due to its very high popularity, the MVC architecture has a such as Model-View-Presenter [10] or Presentation-Abstraction-Control [11].

2.3.2 Details of the Solution to the Cross-Platform Problem in Applications

As mentioned above, the Model-View-Controller architecture has a lot of modifications and is mainly about separating the view layer from the other layers of the application.

The solution to the cross-platform problem proposed in this work bears a clear resemblance to MVC architecture, although it produces similar results related to the principle of operation and correctness of use.

From a technical point of view, the creation of the software in the practical part of the thesis was to write two programs for two hardware platforms. The two programs were supposed to differ only in the graphical user interface, which was due to different operating systems and, in particular, the different purpose of those systems. One of the systems—Microsoft Windows—is a PC-specific system whose graphical interface allows you to display more information on a single screen, unlike the other system, which is Android, which is dedicated to mobile devices, where the data on the screen should be enough for the user to read the most important information for him as soon as possible.

The problem is solved by separating the logic (model) from each program. Because of the different hardware and software platforms, view and controller layers have been merged. Thus, the architecture of each application is a modified version of the MVC architecture, where the view and controller layers are interconnected, while the model layer is a disjointed layer.

The wars of your model are a separate, independent module added to each from the programs. This module is written and compiled in the form of a library saved in the jar format. It includes support for PDF files, i.e. creating them, generating content, and saving them. In addition, it has support for databases, i.e. creating tables, editing their contents and switching between different types of databases.

External libraries, used in the main module, which is part of the two programs, must also be cross-platform. The choice of them depends, among other things, on the hardware platforms on which you want to run. If you are using a library on mobile platforms, pay attention to its limitations and select external libraries that take up as little space as possible and do not overload the oar process too much.

Such a solution brings very large perks for the developer. Corrections, if any, to the logical part of the program or the expansion of its functionality are limited to modifying the code contained in the library. After such modifications, most often there is no need to recompile both programs—required is only updating the jar file, which is the main library in both of these programs. Modifications to the view layer and controller layer code are made only when there is a need to change the appearance of the application or change its response to certain events.

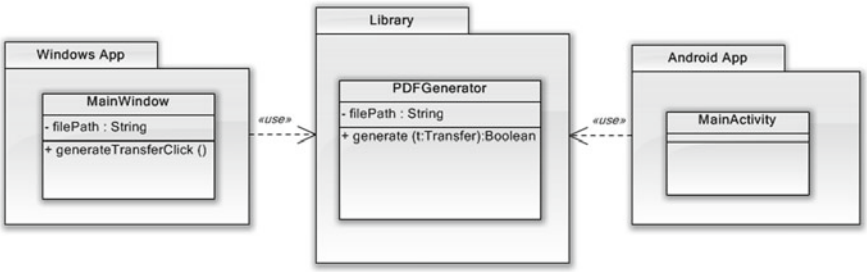

Fig. 3 Simplified diagram of document generator packages Pdf

The solution described above to the problem of cross-platforming in zo-applications has become applied in the practical part of this thesis.

The diagram shown in Fig. 3 is an example that illustrates how to separate a model layer from a view layer and a controller in both applications.

For an application written for Microsoft Windows, the generateTransferC-lick () method is called when clicked on the corresponding button. This method creates a variable of type Transfer, which is then necessary to call the generate () method from an object of the PDF Generator class.

The situation in the Android program is similar. When you press the corresponding button in the main activity of [12], a thread is created and started that processes the necessary data and calls the generate() method from an object of the PDF Generator class.

The PDF Generator class is part of a library that is added to each of the. Programs. This class generates overflow prints, including typing the appropriate information into the appropriate fields in the prints. The iText library (Sect. 3.2) is used to create PDF files.

The remaining functionalities in both programs are implemented in a logical way. Chap. 4 provides a more detailed description of both technologies from a technical point of view, allowing for a more detailed analysis of the author's solution to the problem of cross-platforming in applications.

It is easy to see that creating cross-platform applications is a relatively simple technique, provided that you are familiar with the technical aspects of the programming languages used and the issues related to software engineering. Undoubtedly, getting acquainted with the most common design patterns and their variations facilitates the creation of large IT projects that work regardless of any age of the platforms.

3 Technologies Used to Implement the Practical Part

The following chapter presents selected technologies that have been used to create a cross-platform application that creates overflow prints and cash deposit prints, saved in PDF format. This part of the work also shows how these technologies ensure ing lo platforming.

3.1 Android Platform

The Android system platform consists primarily of an operating system of the same name and a set of programming tools, such as the Android SDK (Software Development Kit) and the Android NDK (Native Development Kit). These tools differ in purpose and in how you create applications. The first is primarily used to create standard applications and facilitates the use of system functionalities. The latter, on the other hand, is more often used by game developers or other applications, requiring direct communication with the device.

3.2 Android Operating System

Android is the most commonly installed operating system on mobile platforms [13]. It is a very powerful system platform for devices such as mobile phones or tablets. It is characterized by very fast development, user and pro-grammatical friendliness of the platform and a perfectly prepared graphical user interface (Fig. 4), adapted to the needs of the owner of the mobile device.

It should be mentioned that the most important feature of this system is that it is open source. This means that all the source code of the operating system and its components is public—it can be downloaded by anyone and modified, added, removed by any line of code, subject to the acceptance of the licensing rules of the manufacturers [15].

The Android platform has gained popularity not only in the environment of programs, which are supporters of "open source", but also among the others—a constant number of developers, thanks to the creation of an open market of applications, where you can list for free or sell programs written for this operating system.

One of the aforementioned main features of this system is the clear, very well-designed graphic interface user. Looking at Fig. 4, you can see that it is simple and contains the optimal minimum of information that the user needs. Regardless of the screen size of the mobile device, the distribution of nets in this interface is similar, ensuring that the user can easily adapt to work with new equipment of a different display size but having the same operating system [14].

Fig. 4 Home screen (left) and main menu (right) of android 4.0 operating system [14]

The Android operating system, thanks to its open-source type, has gained a great many supporting business partners, which has given it so much development opportunities that it is now the best growing operating system on the market [13]. The compatibility of this platform is so great that it can be run on various hardware platforms with different architectures, such as ARM (Advanced RISC Machine), MIPS (Microprocessor without Interlocked Piped Stages) or x86 [16].

3.2.1 Android SDK

The Software Development Kit (SDK) is a set of tools for software developers, necessary to create applications of a given type. Makes it easy to write program language, because it does not require knowledge of the operating system and specifics hardware platform from scratch.

The Android system platform has a very advanced setoff software rows, thanks to which you can, among other things, easily create graphical user interfaces or in an advanced way debug over-code.

The Android SDK connects to java's Integrated Development Environment (IDE), which is most common with Eclipse [17]. This provides a great deal of help to the developer in developing the application, which is the refactoring of Android-specific code, fast fixes for errors in the code, or built-in navigation between the resources contained in the XML files and the program code.

Another important feature of the Android SDKs the tool that creates a graphical user interface. It works on the principle of "drag and drop", that is, moving the corresponding interface elements to a given place in the application view [17]. This

tool has the ability to visualize the screens of various devices, such as tablets or mobile phones. You can change the default color themes of the interface, configure locale and locale settings (including languages), or customize one interface for several devices, on different screen diagonals.

In the default Android application model, the data related to the configuration of the graphical user interface are separated from the lo-tiki layer of the application. This increases code transparency and ease of programming.

Figure 5 of the front shows a portion of the integrated program-mystical Eclipse window that shows the button being moved to where you want it to be in the application.

Listing 5 contains a fragment of the generated XML file, responsible for configuring the button in the graphical interface of the application. This generation occurs as soon as you "drop" the button in the application view.

A single line in Listing 6 is an example of using mechanics, which combines XML file assets and program code. The resource stored in the XML file is moved as a variable btn, which is an object of the Button class [12].

To call the button in Listing 6, which is an XML file resource, methods from the Android SDK libraries were used [12].

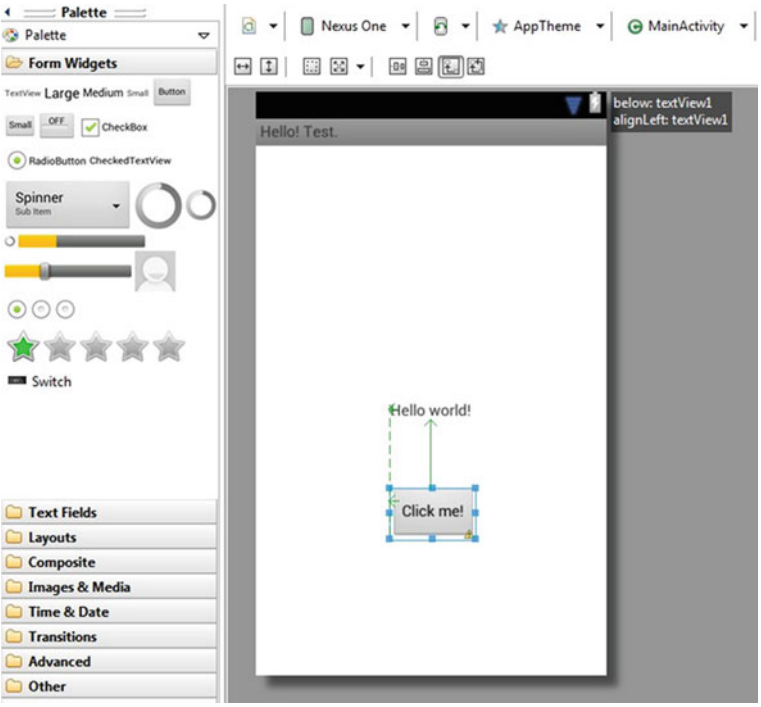

Fig. 5 Example of using a tool to create a graphical user interface in the Android SDK

```
1< Button
2 android:id ="@+ id/ button1 "
3 android:layout_ width =" wrap_content"
4 android:layout_ height =" wrap_content"
5 android:layout_ alignLeft ="@+ id/textView1"
6 android:layout_ below ="@+ id/ textView1 "
7 android:layout_ marginTop =" 62dp"
8 android:text=" Click me! " />
```

Listing 5 Example of using the graphical user interface tool in the Android SDK—a fragment of a generated activity_main.xml

```
1 Button btn = (Button) findViewById(R.id.button1);
```

Listing 6 Example of using a graphical user interface tool in the Android SDK—calling a resource in program code

The aforementioned libraries offer, first of all, the use of any functionalities of the system without the need for direct communication with the plat-hardware form. They also implement the aforementioned solutions that developers use most often. An example of this is the support for the SQLite database, so that working with that database amounts to using a single class [18].

Another important element of the Android SDK development tool is the code debugging module [17]. Its characteristic feature is the debugging of the program on the device on which the program is run. The this sends debugging messages to the computer, which then collects a specialized logcat tool [19].

In the absence of a physical target device, the Android tool.

The SDK has a hardware platform emulator with Android systems installed. This allows the programmer to run the program on multiple virtual devices, making the application more reliable and resistant to changes in the environment.

3.3 iText Library

iText is a cross-platform library for SUPPORTING PDF documents. It was written in Java by Bruno Lowagie. There is an equivalent written in C# called iTextSharp.

PDF (Portable Document Format) is an open file format (status—dard ISO 32000-1), created by Adobe [20]. Files saved in this format are most often text and graphic documents, the value of which is independent of the hardware platform and systemin which they are opened. Thanks to its portability, it is the most commonly used for-mat for recording various types of documents.

iText is a library created primarily for creating, modifying, and opening PDF documents [20]. It offers primarily automatic creation of documents, their conversion, digital signing, encryption, extraction of data from a file. It also enables various types of data processing and entire files in pdf format, for example, linking documents.

One of its main features is the creation of an on-the-fly document—that is, its contents may not be known in advance—can be calculated or otherwise processed during the creation of the document. In addition, the library's operation is aimed at "mass" file generation, so it can be run inside program code or called in executable files accordingly [20]. It also has a built-in mechanism for cooperation with databases and XML files, containing the content of generated documents. Its great capabilities and wide application have made it an excellent solution for software manufacturers.

The programmed player is offered two approaches to creating PDF files using the iText library—one of them is "higher" and the other "lower" pozio-mu.

The first works on the principle of adding new chapters, subchapters and new paragraphs (paragraphs) to the document. This is a good solution for creating a simple document with a uniform plan.

Listing 7 presents the simplicity of this solution. In the beginning, a new document was initiated to create an instance of the Document class whose implementation is in the iText library. The source of the created document instance is then defined. On the third line, the document is opened for editing, and in the next line there is a new.

"Hello World!". The last line finishes editing the document and generates the resulting pdf file. Figure 6 before—puts a fragment of the generated file.

In the lower-left corner of the window in Fig. 6, you can see the page size in the document. This is the standard size of the A4 format. iText has the ability to modify the page format, page size, and many other settings based on overwriting the default configuration. This configuration is adapted to the most common page size,

```
1  Document document = new Document();
2  PdfWriter. getInstance (
3       document , new FileOutputStream("document.pdf"));
4  document.open ();
5  document.add (new Paragraph(" Hello World ! "));
6  document.close();
```

Listing 7 An example of creating a PDF document that contains a paragraph with any inscription [20]

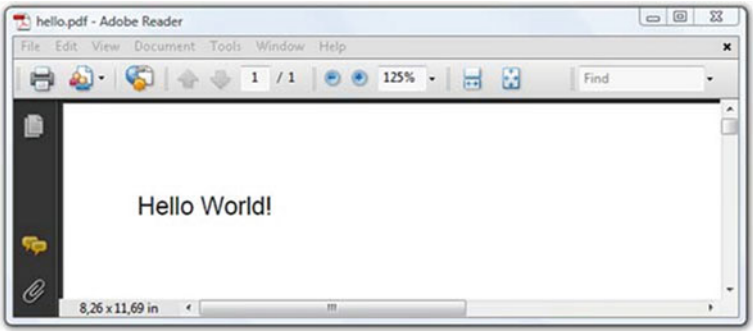

Fig. 6 A portion of a PDF document created, for example, using iText [20]

```
1 Document document = new Document ();
2
3 PdfWriter writer = PdfWriter.getInstance (
4            document, new File OutputStream ("document.pdf"));
5
6 document.open();
7 PdfContentByte canvas = writer.getDirectContentUnder();
8
9 writer. setCompression Level(0);
10
11 canvas . save State();
12 canvas . begandn Text();
13 canvas . move Text (36, 788);
14 canvas . setFontAnd Size ( BaseFont. createFont(), 12);
15 canvas . shoin Text(" Hello u World ");
16 canvas . end Text ();
17 canvas . restore State ();
18
19 document.close();
```

Listing 8 Example of creating a PDF document using page coordinates [20]

its style, and therefore the creation of simple documents does not require a change in the settings, which makes programming much easier.

The second method of creating documents in the iText library involves drawing primitives and writing text, using only the page coordinates in the document. To achieve the same effect as in Fig. 6, it is up to you to replace the code from Listing 7 with the 8. listing code.

The beginning of Listing 8 is identical to Listing 7. Later on, an object is created so that you can navigate the coordinates of the document. “Hello World!” is then written out. coordinates and using the appropriate font size. Finally, the edit of the document is closed, and the resulting file is generated.

It is not difficult to notice that the implementation of the first method using the Paragraph class (Listing 7) uses a method based on the use of page coordinates in the document. Moreover, these techniques can be combined with each other.

One of the main objectives of iText is its cross-platformness [20]. This cross-platform and portability has been ensured by the use of tools integrated into Java as standard. This library does not use any additional external tools, so it can be run on any system and hardware platform on which it is sufficient to be able to install a Java virtual machine.

3.4 Databases Used

In the practical part of this thesis, databases were used to record information from prints. You can choose between two types: PostgreSQL and SQLite. To avoid repeating the code associated with two database implementations, the ORMLite bibliote, which implements object-relational mapping (ORM), was used.

Object-relational mapping is a way of mapping data stored in object-oriented form to a relational form used by relational databases, and vice versa [21].

Orm-based tools (for example, Hibernate [21] or ORMLite [22]) are intermediaries that replace object data with the appropriate tuple in database tables, and vice versa. This improves programming because the developer only process objects, forgetting to work with the database.

3.5 ORMLite Library

ORMLite is a portable, cross-platform library based on object-relational mapping. It was written in Java. It is used to move data from objects to tables in databases, and vice versa. Ensures proper collaboration with mobile platforms. It works properly with the Android operating system, also providing support implemented in the system.

3.6 SQLite Database [22]

This library contains all the necessary tools for communicating with any database to which the jdbc driver has been released. ORMLite works with the structure of the classes to be presented in re-combined form by annotation [2, 22].

The code in Listing 9 contains a sample class, consisting of two String fields, first name and last name. Annotations contain information for the ORMLite library, such as the table name, the corresponding class, or the name, type, and properties of the columns that correspond to the table fields.

For example, you need to write a new Account object to the database. The corresponding component in the library searches for a table named "accounts" (all names are related to those of Listing 9). If there is no such table, it creates it. Then, in the "name" column, type the value of the field in the object's name, keeping in mind that it is the primary key. Similarly, the remaining columns of the table are rested.

```
1 Database Table ( table Name = " accounts ")
2 public class Account {
3
4 @ Database Field ( id = true , column Name = " name ")
5 private String imie ;
6
7 @ Database Field ( column Name = " password ")
8 private String haslo ;
9
10 // ...
11
```

Listing 9 A fragment of the Account class that represents the work of the library ORMLite [22]

The example above shows the benefits of a cross-platform ORMLite library. Another facilitation is to change the type of database used his is limited to changing the address of the server or the file in which the other database is located.

3.7 SQLite and PostgreSQL Database

SQLite is a freely available and open database system, named and operated through libraries that are created that support Structured Query Language (SQL). A characteristic feature of these systems is the fact that the contents of the database are kept in a single file, which can be up to 2 TB in size (this depends on the file system and operating system). This database is saved as a binary and is constructed using B-trees. This system, despite its simplicity, is very extensive and includes transactions, foreign keys, views, nested queries. With high performance and low system resource consumption, these databases are used in a variety of devices, including mobile devices [23].

PostgreSQL is a much more extensive database system than SQLite. A database is not a single file on a user's disk but requires a server. It has a theoretically unlimited database size and the maximum size of a single table is 32 TB [24]. Its ness compared to the previously described system is expanded with, among other things, new data types or rules that are used as an extension of views. PostgreSQL works on a large number of hardware architectures, such as x86, x86–64, PowerPC, ARM, MIPS.

Both types of databases described above enable you to work with applications running on different system platforms and hardware. A prerequisite for the cooperation of the database with a program written in a specific programming language and operating on data platforms is the existence of a driver to this database that runs in your environment. Java refers to jdbc drivers, an example of which is shown in Listing 10.

To the program, a fragment of which shows the code contained in Listing 10, to—added ORMLite library and drivers for the databases PostgreSQL and SQLite. Libraries and these are saved in jar format. The cross-platform Orm-lite tool ensures that the code of this program is run on each of the platforms mentioned by the author.

```
1  String POSTGRES_ URL =
2  " jdbc : postgresql :// adres - serwera . com / nazwabazy " +
3  "? user= uzytkownik & password = haslo ";
4
5  String SQLITE_ URL = " jdbc : sqlite : plik . sqlite ";
6
7  Connection Source postgres = nein Jdbc connection Source (
POSTGRES_ URL );
8  Connection Source sqlite = nein Jdbc connection Source (
SQLITE_ URL );
```

Listing 10 Creating connections to two databases in the program

Therefore, it is possible to connect to the SQLite and PostgreSQL databases using a Listing 10 program on all platforms for which it is possible to install a Java virtual machine.

To sum up, most of the most popular technologies provide two-way applications knowledge platform. Each type of database works with most client programs because of the existence of appropriate drivers. Cross-platforming therefore gives more interest in the product in the IT market because the end-user is not about the bordered barrier- me compatibility.

4 Design of Applications for Creating Overflow Prints and Prints for Cash Deposits

The purpose of the practical part of this thesis was to create a project—here, consisting of two applications: one of them was to run Android, while the other was to be written for Micro-soft Windows. The purpose of both programs was one—the creation of transfer prints and cash deposit prints, which are saved as a PDF file. In addition, data from these documents are to be stored in one of two databases: SQLite or PostgreSQL.

The following issue contains, from a technical point of view, issues related to the with the above-mentioned project.

4.1 Description of Project Requirements

Before creating all the elements of both applications, you had to define and put together all the functional and non-functional requirements of the project.

The functional requirements of the created applications are as follows (Fig. 7):

1. Portable cross-platform library, which is part of the logic of both pro-grams:
   - separation of the logic layer (model) from the view layer and the troller in the Android and Microsoft Windows applications.
2. Generate transfer prints and prints for cash deposits that are saved to a PDF file:
   - creating a PDF file using the iText library (Sect. 3.2),
   - creating a graphical representation of printing,
   - validation and generation of data necessary for printing,
   - entering the necessary data into the graphical representation of the printing.
3. Saving information from prints to a database:
   - connection to the PostgreSQL and SQLite databases (Sect. 3.3),
   - Add, edit, or delete data in databases

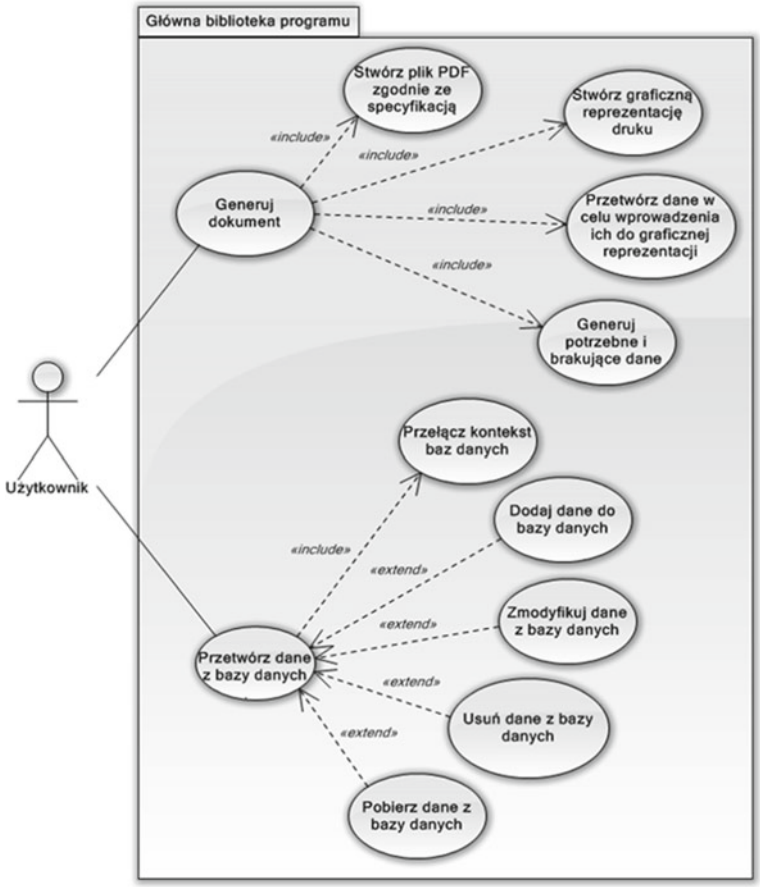

Fig. 7 Use case diagram that illustrates the functional requirements of a project

- switching between different types of databases.

Figure 7 shows a diagram of the use cases, showing all the above-mentioned functional requirements. Figure 8 shows an action diagram that includes adding a new entry to the "transfer history" in the database when you press the print button (using "Add data to database"). Figure 9 illustrates a communication diagram that shows the situation where interface retrieve data from a database (the "Download data from database" use case).

To facilitate readability, the messages in the diagram shown in Fig. 9 are stored in the pseudo the code. The Database class comes from a main, cross-platform library. The Dao Manager class is a class derived from the ORMLite library that is attached to the aforementioned main module, which is part of the logic of both programs. As you can see in Fig. 9, the user's interferes is an actor—it can be a program written for the Android or Microsoft Windows operating system. This confirms the main

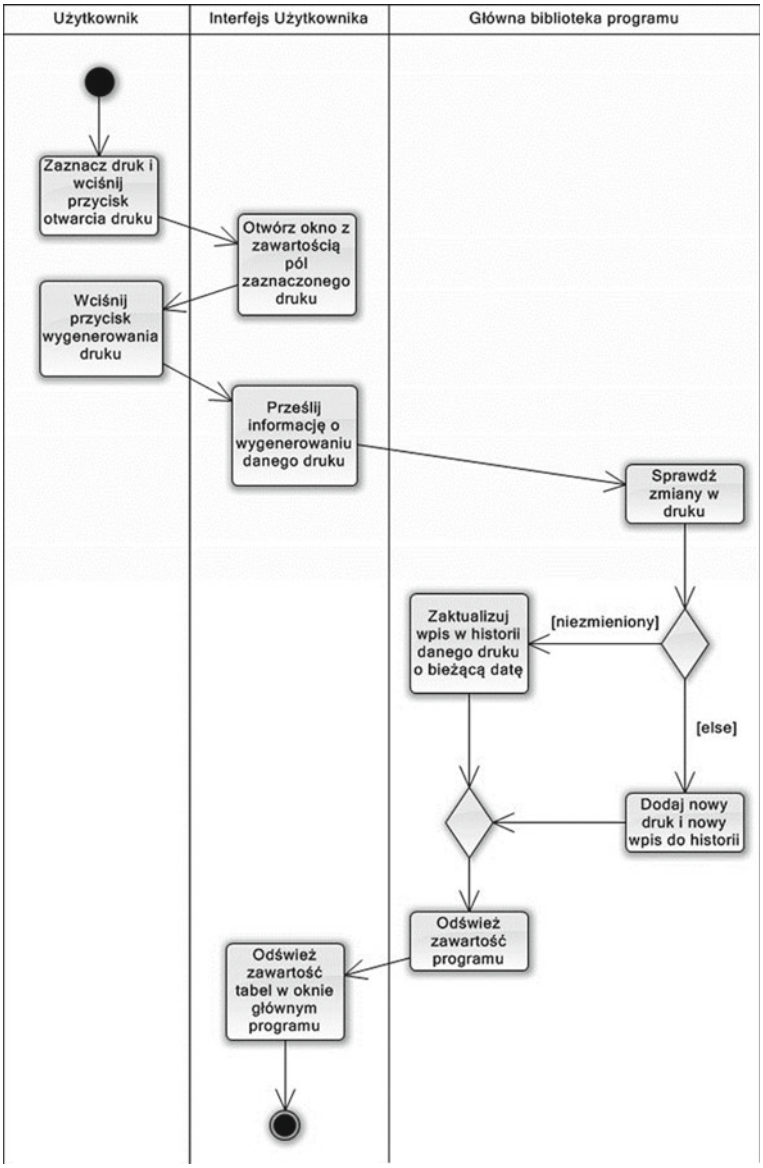

Fig. 8 Action diagram showing how to add a new entry to a "transfer history" in the database

assumptions of the author's way to solve the cross-platform problem in applications, which is described in Sect. 2.3.

The non-functional requirements of the project are:

- Unified, similar graphical user interface in both applications.

Fig. 9 Communication diagram showing the UI's retrieval of data from a database (use case "Get data from database")

- Arrangement of items in program windows to resemble hand-filled overflow prints and cash deposit prints.

Unifying the graphical interface makes it easier for the user to switch between using an application dedicated to PCs and using an application written for mobile devices and vice versa.

Setting the elements of the graphical user interface in such a way that it resembles the setting of fields in hand-filled prints makes it easier for the new user to navigate the program and increases the intuitiveness of the application.

4.2 Data and Logic Layer

The project, which is a practical part of this thesis, consists of three modules. Two of them are applications presenting a graphical user interface for Microsoft Windows and Android. A third part is connected to these applications, which is the main library, containing all the necessary functionalities.

4.2.1 Diagrams of Project Module Classes

The following are diagrams of the classes of the three parts of the project. The first is the main library, which is the logical layer of the other two parts, namely applications for Android and Microsoft Windows main library.

Figures 11, 12 and 13 show diagrams of the classes of the main part of the project, which is the main module, in which all non-redundant functionalities are implemented. Due to limited space, some clowns do not display private attributes and operations.

To show the dependencies between all classes contained in the main library of both programs, Fig. 10 provides a diagram of the main module packages. As you can see in this figure, the packages are loosely connected to each other. This is because each of them is used separately in each of the two programs created.

The library package (Fig. 12) has classes that provide the functionalities necessary for creating overflow prints and independent library launch. Pdf Generator methods are used to generate a PDF image file using an external iText library. Parser methods

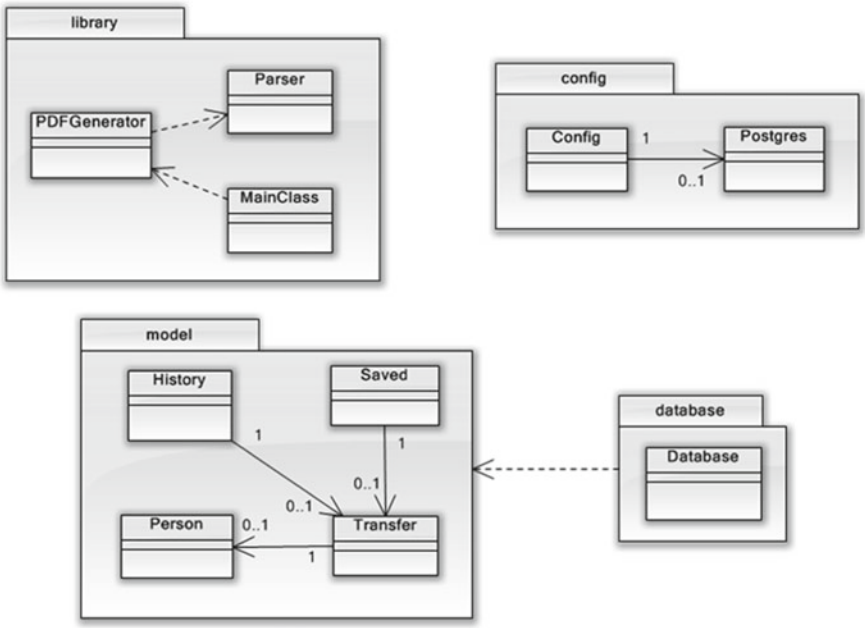

Fig. 10 Diagram of the main library packages used in Android and Microsoft Windows programs

they are tasked with replacing numbers with appropriate strings, and vice versa—this is used to populate the document with data. The Main Class is the main class that will generate an empty print for cash deposit by running the library itself.

The config package (Fig. 11) and the classes contained therein are responsible for rearming and saving the application configuration. Settings are written and read from a defined XML file.

The database package (Fig. 11) and its Database class are used to support databases. The model package (Fig. 13) contains classes whose objects are necessary for object-relational mapping. ORM is used by the external ORMLite library, working with the Database class.

- Android app

Figure 14 shows a diagram of the classes that make up the Android application. This diagram does not show private attributes and class operations. The Main Activity, Settings Activity, HSFragment classes contain the implementation of the appearance of the application and the capture of events from the user. The DataGetter, DataSetter, and DataRemover classes are the lines that support the database. The Items class has up-to-date data to be displayed to the user. All of these classes, of course, use the services of the main library that is included in the program.

- Application for Microsoft Windows

For an application written for Microsoft Windows, the class diagram is in Fig. 15. The MainWindow, AddEditDialog, PersonsDialog, PersonsAddEditDialog, AboutDialog, and SettingsDialog classes are responsible for the appearance of the application and the capture of user-derived events. The DialogMethods class is responsible for the logic in the graphical interface of the user—it implements, among other things, a mechanism to prevent typing letter in the field where you type a number. The SavedTableModel, HistoryTableModel, PersonsTableModel classes are used to ensure that prints are displayed correctly in the main window of the program and in the customer and customer management window (Figs. 18, 20, 24, and 32).

4.2.2 Schemata Database Used in the Project

The user has the option to choose between two types of databases, where to save information about transfers. This is to increase your work with both Android and

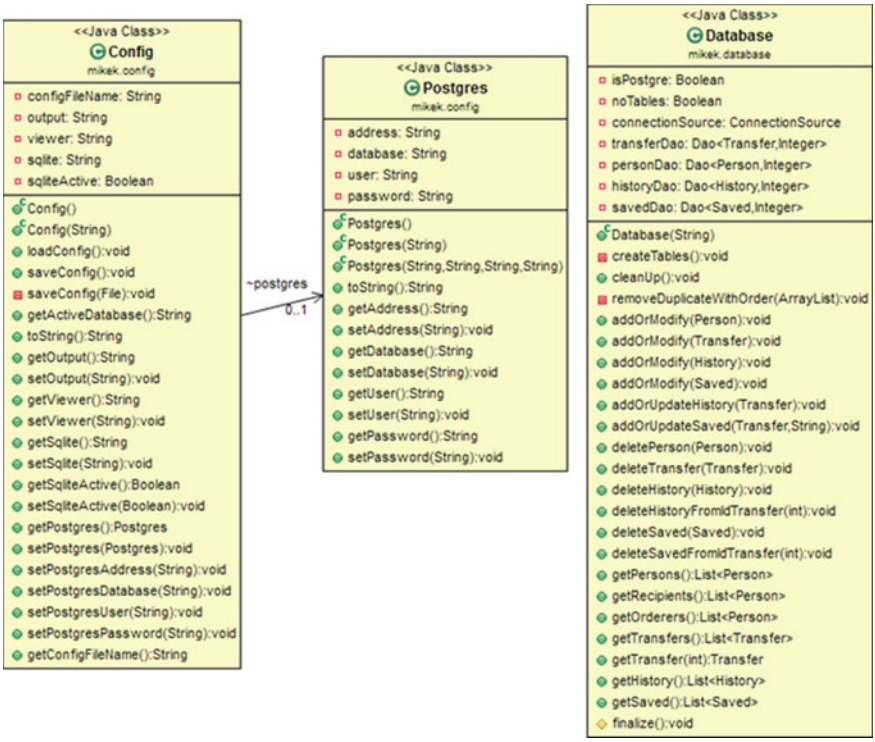

Fig. 11 Diagrams of the main library classes—config and database packages

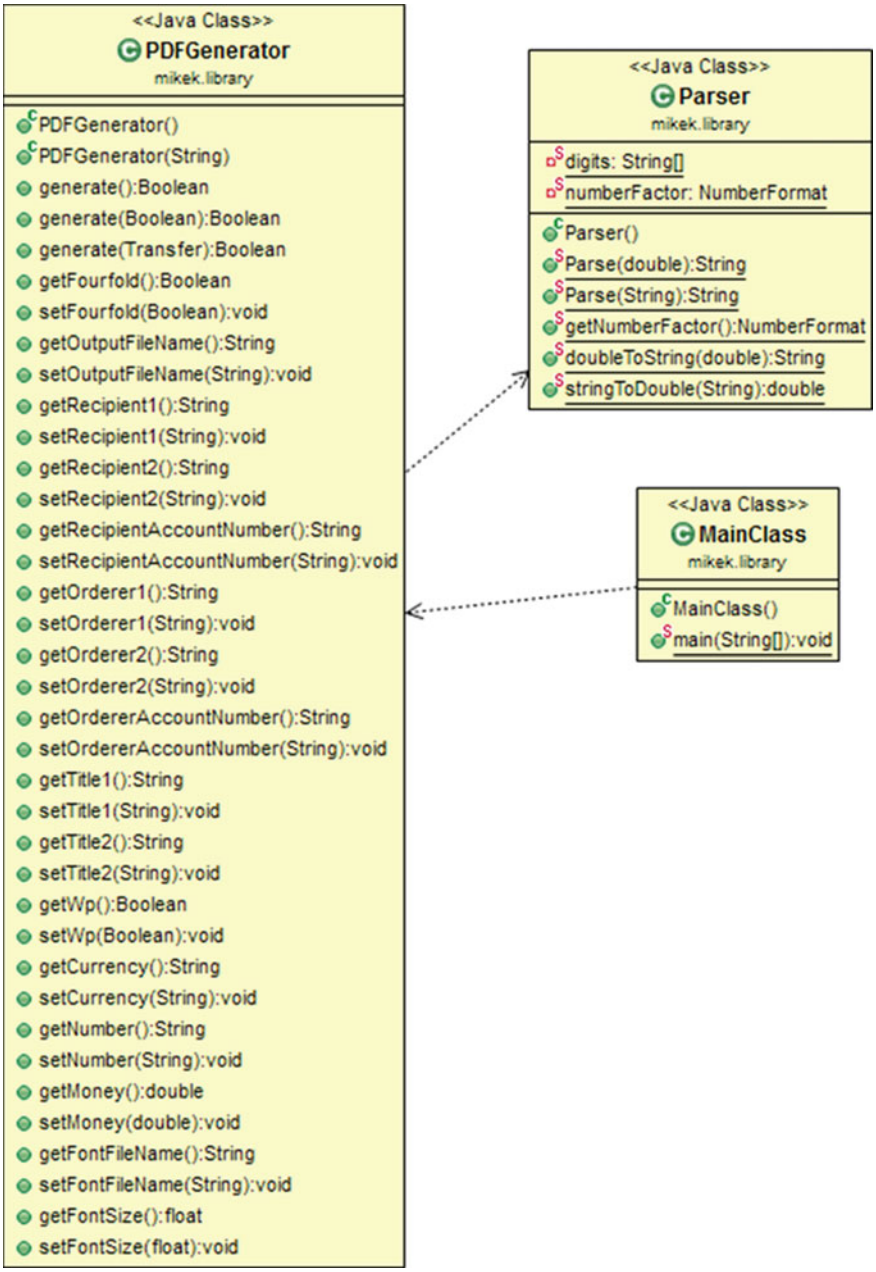

Fig. 12 Master library class diagram—library package

Microsoft Windows. To have the same data in both programs, select the PostgreSQL database because its server is in a location accessible to both devices so that the

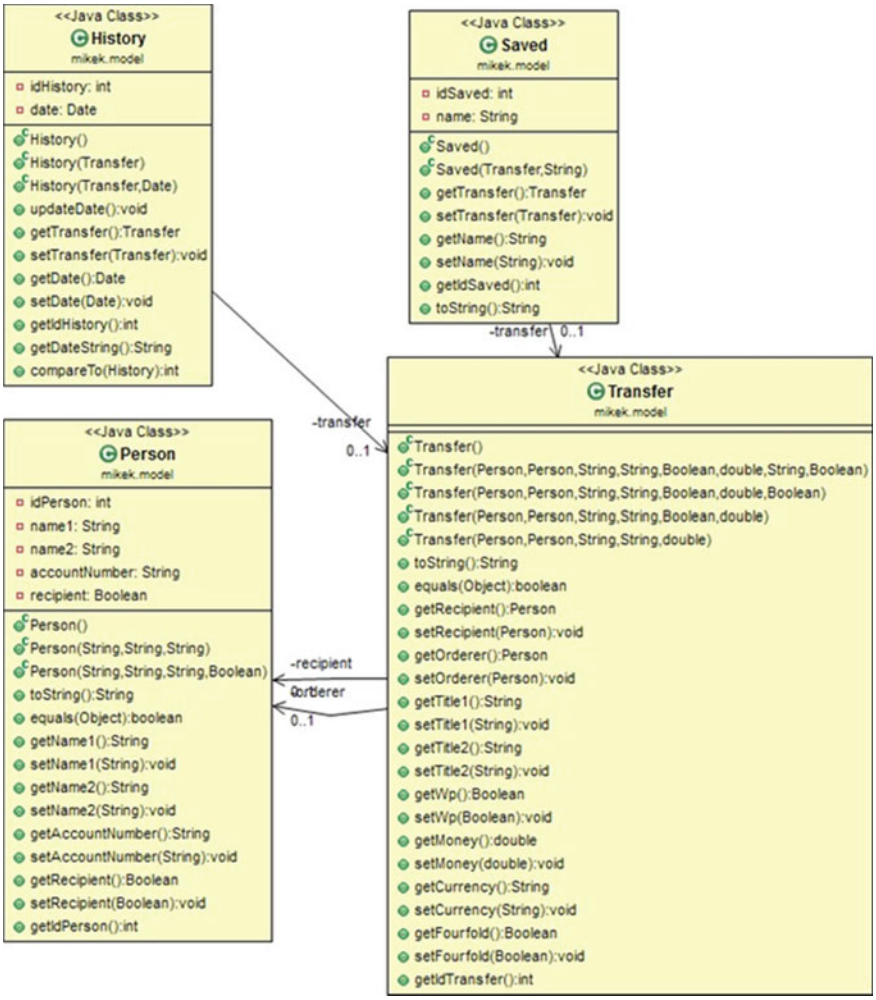

Fig. 13 Main library class diagram model package

information is synchronized. If you will only use one type of application, simply select the SQLite database.

Figure 16 shows the database scheme used in both PostgreSQL and SQLite. The tables in the database are designed to make connections between them simple and to be able to expand the system seamlessly in the future.

The Transfer table contains all generated prints, History has prints saved in history along with the date of the last generation, saved documents are stored, marked with the appropriate name, and in the Person table you can find the data of the principals and recipients.

In Fig. 16 The *Transfer* table contains all generated prints, *History* has prints saved in history along with the date of the last generation, saved documents are stored, *marked* with the appropriate name, and in the Person *table you* can find the data of the principals and recipients.

In conclusion, creating a cross-platform project consisting of two applications for two different systems requires the developer to choose the right tools and technologies to develop this type of software. In addition, after analyzing the requirements and functionality of the project, you must choose the appropriate method for creating both programs. For this thesis, a proprietary solution to the problem of creating cross-platform applications is similar to the MVC pattern (Sect. 2.3).

5 Presentation of Applications for Creating Overflow Prints and Prints for Cash Deposits

The following chapter describes how to use applications that are part of the practical part of this thesis two applications have been developed—one for Microsoft Windows and the other for Android. Both of these thresholds have one goal—to handle and create prints for cash deposits and overflow prints. Both applications have been tried to maintain a similar look, so this support description applies to both programs.

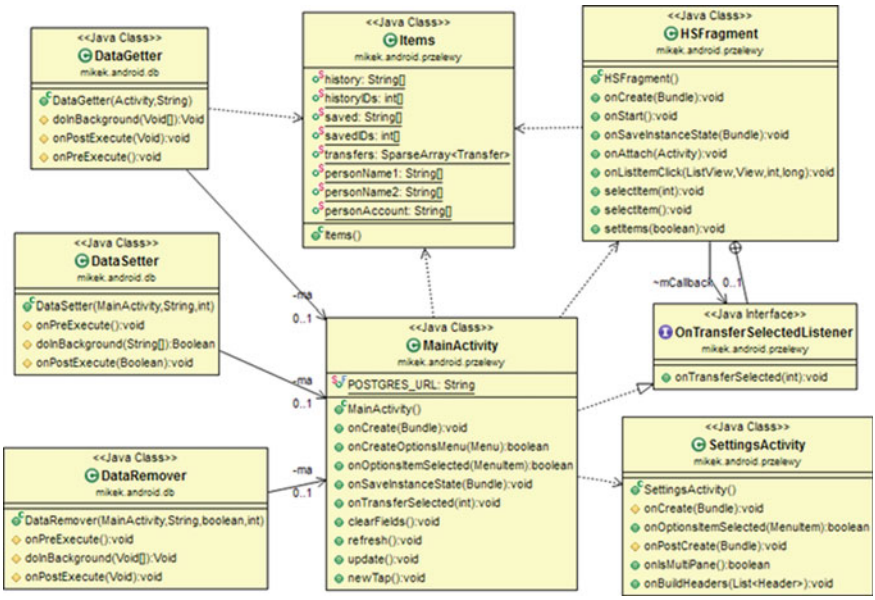

Fig. 14 Android app class diagram

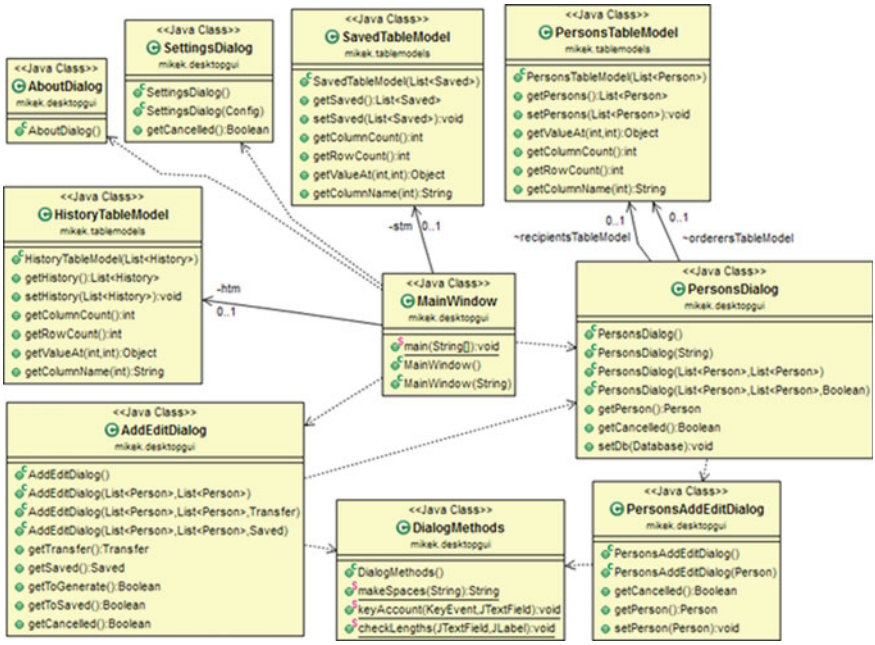

Fig. 15 Microsoft Windows application class diagram

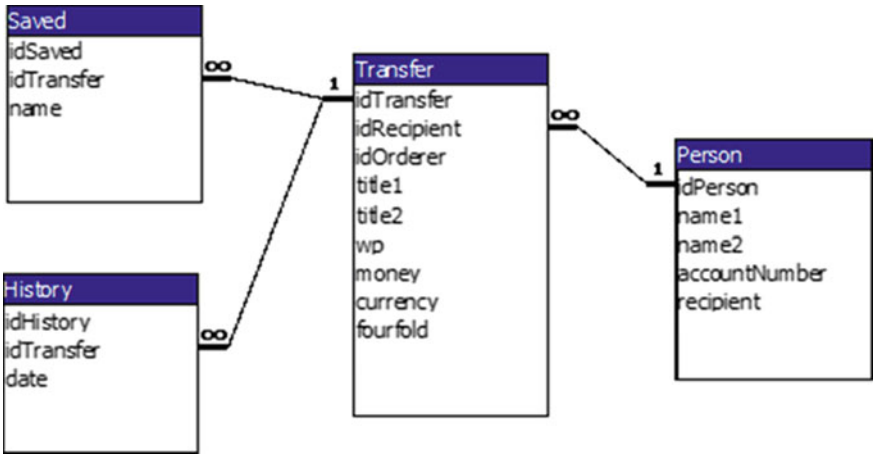

Fig. 16 Android application database diagram and Microsoft Windows

Both applications are connected to the same PostgreSQL database for presentation purposes, so both applications have the same transfer information.

5.1 Main Application Window

The main application window appears as soon as the program starts. In the descriptions- the main window has two parts—one displays the history of transfers, the other shows transfers, saved in the database.

Both parts can be switched between each other in different ways, depending on the pro-gram. Switching between transfer history and transfers saved on Android (Figs. 17 and 19) is done by pressing the program icon in the upper left corner of the screen. In the Application for Microsoft Windows (Figs. 18 and 20) there is a bar, containing two tabs: "Transfer History" and "Saved Transfers", which is used to switch between two types of transfers.

The Android app has a menu bar at the top of the program (Fig. 21). The icons displayed in this menu indicate, in turn: creating a new transfer (plus icon), deleting the transfer (icon "trash"), fill in the customer field with the data of the selected person or show the people stored in the database. Another field is the name, which means transfer in the list of saved transfers. The next button generates the transfer and saves it to the history and if the name field is not empty, it also saves it to the "saved transfers" item. The last button marked three—has dots arranged vertically, expands an additional menu in which you can update the data in the program by downloading

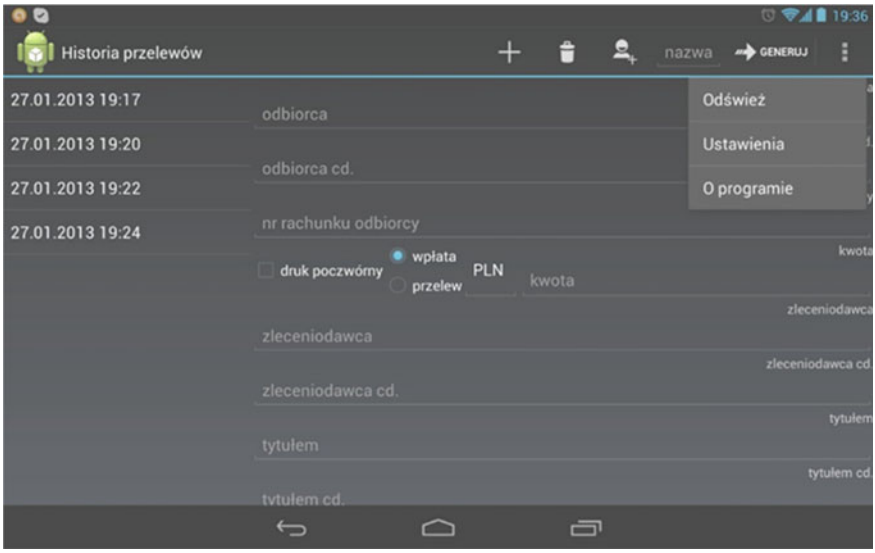

Fig. 17 Android main window displaying transfer history

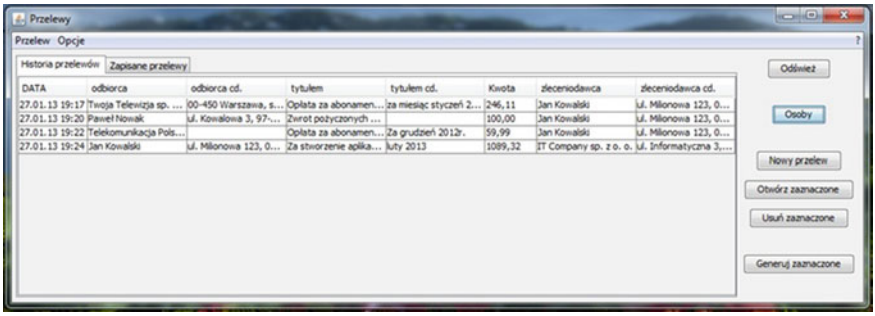

Fig. 18 Microsoft Windows Main Window showing transfer history

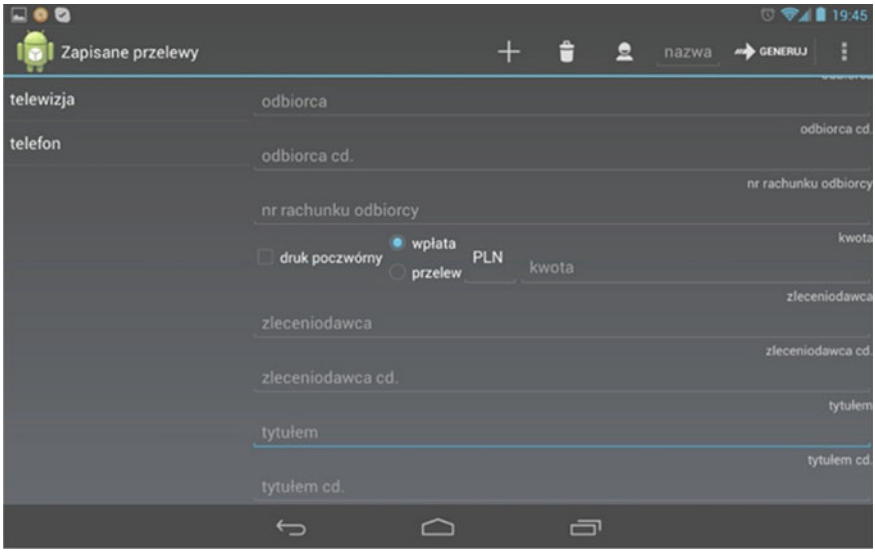

Fig. 19 Android program main window displaying a list of saved transfers

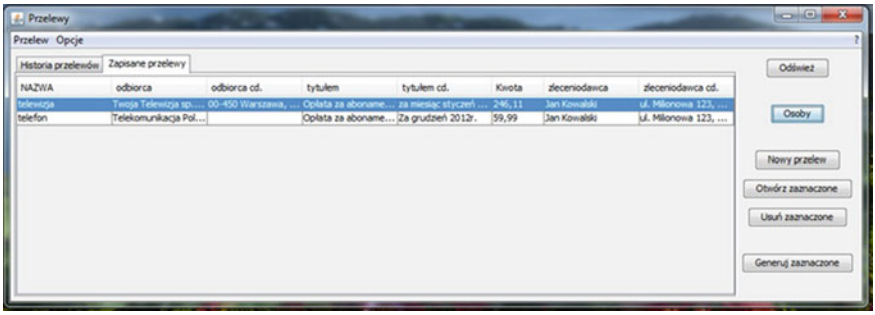

Fig. 20 Microsoft Windows Main Window, showing a list of saved transfers

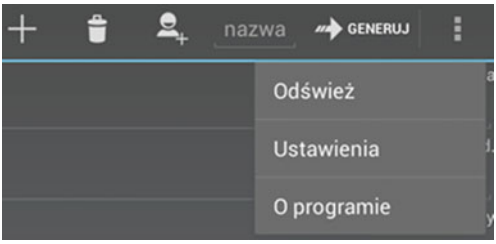

Fig. 21 In-app menu bar for Android

it from the database; program or open the author window. Refreshing the contents of the program also takes place when the device is rotated from an upright position to a second position or vice versa.

In the main application window for Microsoft Windows (Figs. 18 and 20) there are two parts responsible for navigating the program—one of them is the menu bar located at the top, and the other is a list of buttons located on the right side of the screen. The menu bar and button set perform the same actions that are analogous to those described for Android apps.

All the functionality described above is explained in detail in the following section.

5.2 Create a New Transfer

In both programs, you create a new overflow print or cash deposit printing in a different way.

In the Android app, if you want to create a new transfer or clear filled-in fields, simply press the button marked with "+" (Fig. 21). Then all fields of the form will be cleared, and no saved transfer will be selected, as shown in Fig. 19.

For Microsoft Windows applications, to create a new print, select New Transfer (Fig. 22) on the Transfer menu, or press the button with the same name to the right of the main program window (Figs. 18 and 20).

Figure 23 shows the window responsible for creating a new transfer. All fields are arranged in a manner analogous to the generated printing. On the right, in the section defining the recipient and the customer, there are buttons responsible for filling in the wrong fields with the data of people stored in one of the databases, which are selected in a special window (Sect. 5.3). At the bottom of the screen are the Gene-ruin, Generate and Save, and Save buttons. The first one is used to generate document and save it only in the transfer history. The second, on the other hand, builds the functionality of the first button to save the transfer to the list of saved transfers. The last button only saves the print without generating or saving it in history.

Both applications control the content that you enter into text box data, so you cannot enter letters into the amount field, for example. Additionally, the fields that specify the number of the unku are formatted. This formatting divides the text into blocks of four digits, as usual, the account number is written "manually".

5.3 Add Saved People to a Transfer

As mentioned in Sect. 5.2, both applications remember the reception data and payers in order to facilitate the filling out of overflow and cash deposit prints.

To add a saved recipient or requester to print in a Microsoft Windows application, press the appropriate button to the right of the window in Fig. 23. The button in the upper right corner (grayscale character icon) starts a window that fills in the customer name, customer name, and customer account number fields. The button below starts the same window, but the name of the client, the name of the client cd. and the client's account number are full. The window that adds the recipient or requester is shown in figure toward Fig. 24.

When you press the button responsible for adding the recipient, the window shown in Fig. 24 is displayed, with the Recipient tab active. If you press the button responsible for adding the order donor, the same window is displayed, but with the Customer's active tab.

Of course, it is possible to fill in the recipient's field with the data of the person who is the principal, and vice versa—you only need to switch to the appropriate tab in the window, located in Fig. 24.

In the Android app, adding a saved recipient or requester to print is done in a similar way. If the text input cursor is in any field associated with the requester or recipient, the icon on the third item in the menu (Fig. 21) to—is given the character "+". When you press the button marked with this icon, the person selection window shown in Fig. 25 appears. When you select the appropriate customer or recipient, the fields on which the cursor is located are filled in with the selected person.

When you press any of the buttons at the bottom of the screen, before you appear in Fig. 23, or press the GENERATE button on the screen in Fig. 17 or 20, you are also added to the database, if any, even if you select any of the already saved persons and changed anything in the fields of the order or or recipient.

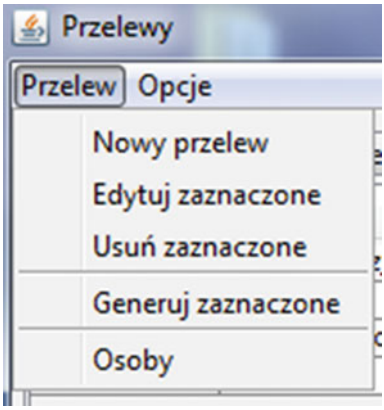

Fig. 22 In-App transfer menu for windows

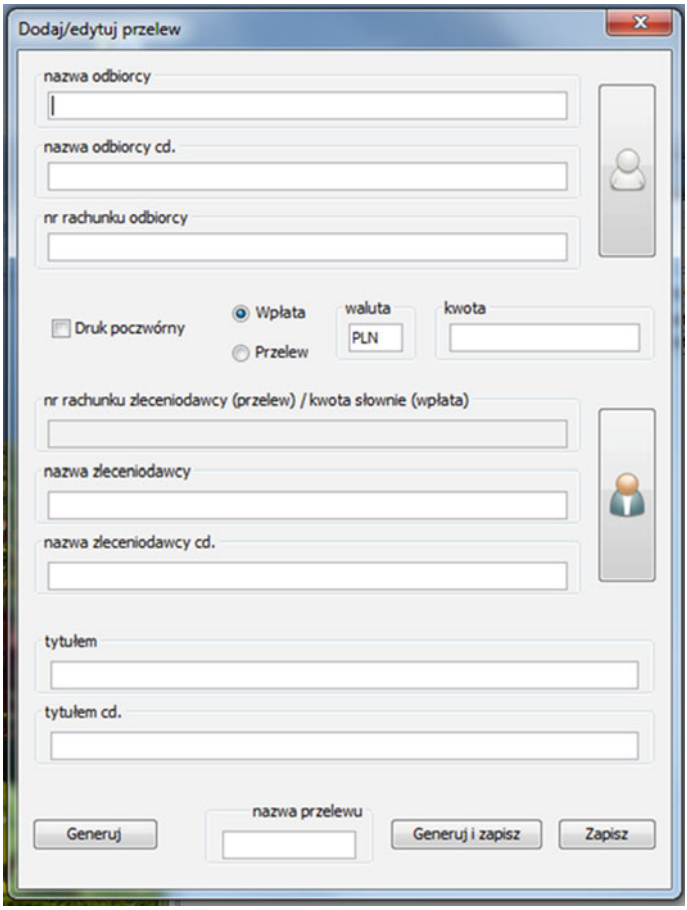

Fig. 23 Window creating a new transfer in a Windows app

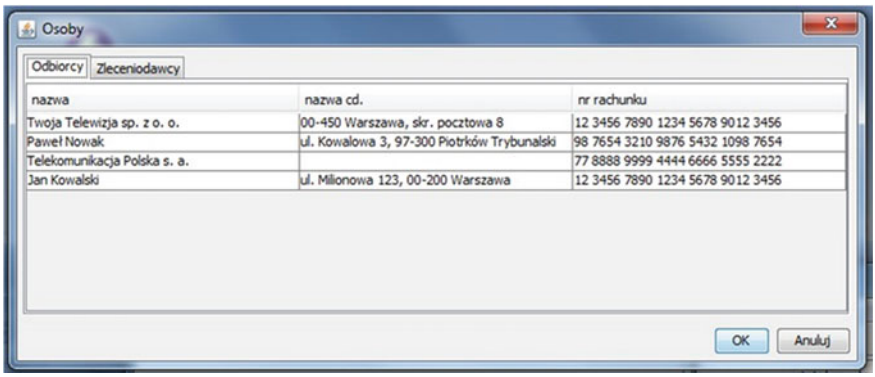

Fig. 24 Window for adding a customer or requester to a transfer in an application for Microsoft Windows

Fig. 25 Window for adding a customer or requester to a transfer in an Android app

5.4 Generate Prints

After filling in the necessary fields in the print form, most often it is time to generate it and, depending on the user's preferences, send it or print it. The generation activities in both programs are even identical.

For Android apps, press the GENERATE button in the menu bar (Fig. 21) to generate print. Then, in addition to creating a PDF document, the print is added to the history in the database. If the name field is full, this additional print is saved to the "saved" position in the database. The PDF file is stored in the root directory of the device's memory card and opened by the default file viewer, which is configured directly on the system.

In a Microsoft Windows application, printing can be generated equally in the main program window (Figs. 18 and 20) as well as in the windows of new printing and opening of the print (Fig. 23). They are used for this intuitively marked at—The file is saved in a place on the disk, marked with the path specified in the settings (Sect. 5.8) and opened using a program that is also stored in the settings.

Figure 26 shows an example print that was generated by one of the programs. In addition, it has been saved to the transfer history, as shown in Fig. 27.

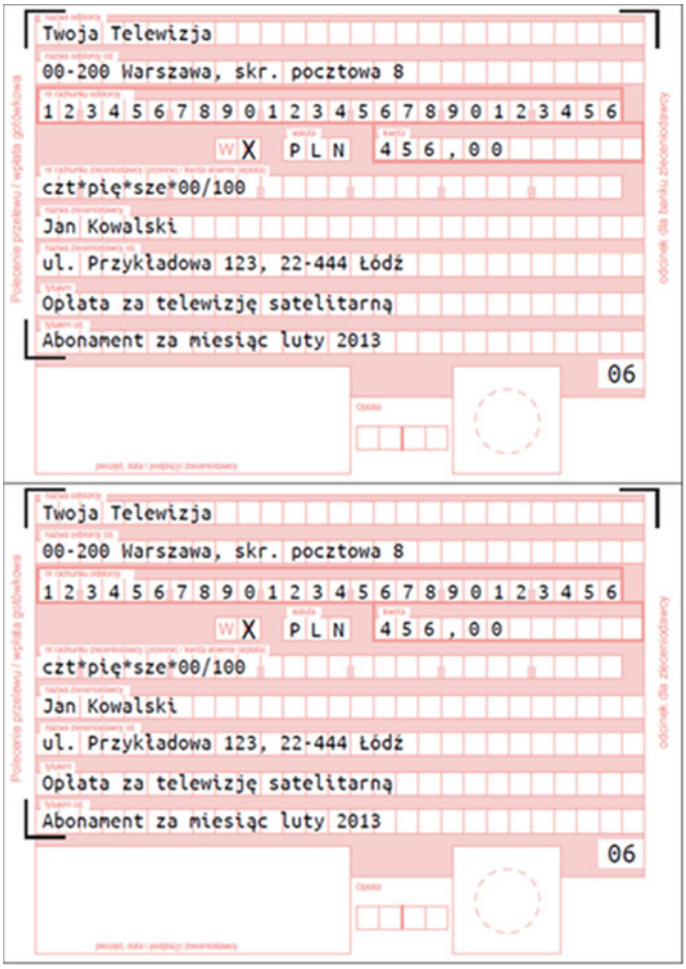

Fig. 26 Sample cash deposit printing generated by one of the programs

Historia przelewów | Zapisane przelewy

DATA	odbiorca	odbiorca cd.	tytułem	tytułem cd.	Kwota	zlecenio...	zleceniodawca cd.
17.02.13 19:14	Twoja Telewizja	00-200 Warszawa, s...	Opłata za telewizję satelitarną	Abonament za miesiąc...	456,00	Jan Kowalski	ul. Przykładowa 123

Fig. 27 History entry created as soon as printing is generated

5.5 Open and Edit Saved Print

Opening or editing saved prints is done in a similar way to creating new documents (Sect. 5.3).

In the main window of the application for Microsoft Windows, you must know whether the transfer to be opened, as done in Fig. 20. Then you need to press the Open Transfer button. A window similar to the one that opens when you press the New Transfer button appears, but it will be filled with relevant information. This situation is illustrated by the screen shown in Fig. 28.

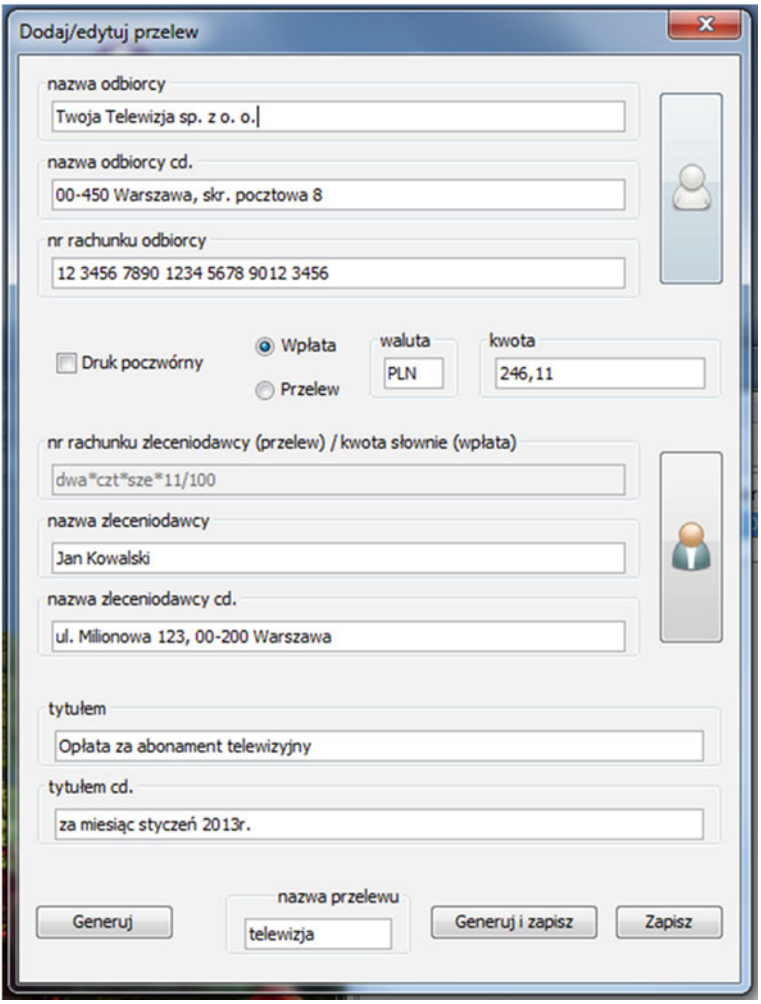

Fig. 28 Window to open printing in a Windows app

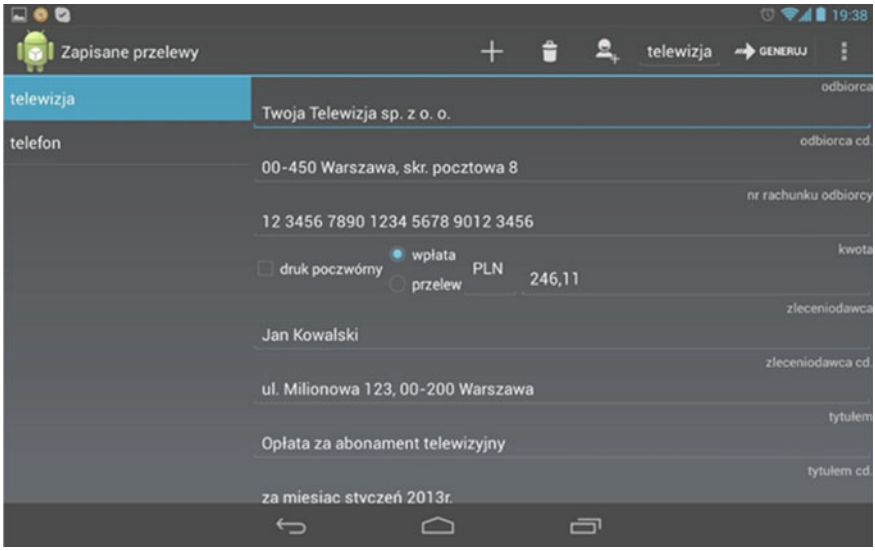

Fig. 29 An example of open print in an Android app

The remaining steps are the same as creating a new print. If you press the button that generates the PDF file and do not change any fields in the deposit or transfer, then only the print date in the history will be updated. In the opposite case, a new entry will be created in the Transfer history. Similarly, when printing is written to the "saved"—if the name of the transfer changes, a new entry will be created. Otherwise, the print with the same name will be updated.

For Android apps, just tap the "saved transfers" list or "transfer history" to open and edit the print. Then all the fields are filled in, which allows you to directly generate the document or edit it—this is shown in Fig. 29.

5.6 Delete Prints

To delete a print in a Microsoft Windows program, select the item in the table and press the Delete Transfer button (Fig. 20). A window will then appear asking you to confirm the deletion, as shown in Fig. 30. Once confirmed, the entry will be deleted from the "transfer history" or from "saved transfers" and the content of the program will be re-downloaded from the database.

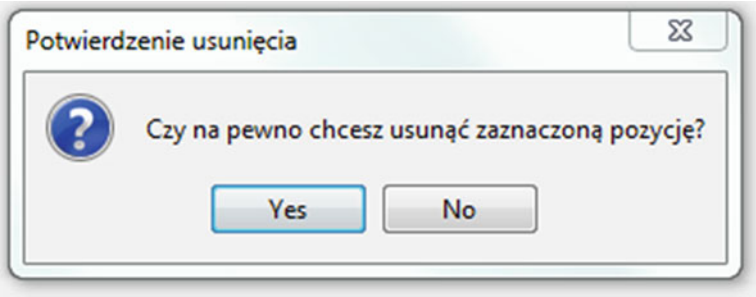

Fig. 30 Message asking you to confirm that you have removed the print from the "transfer history" in the Windows app

To remove a particular print in an Android program, follow the same procedure as in Microsoft windows program. The button responsible for removal is located in the menu bar and is marked with a trash can icon (Fig. 31). When you press it, a window appears to confirm the deletion, as shown in the picture.

Figure 31 After a positive response, the transfer is deleted, and the pro-gram is updated in accordance with the current contents of the database.

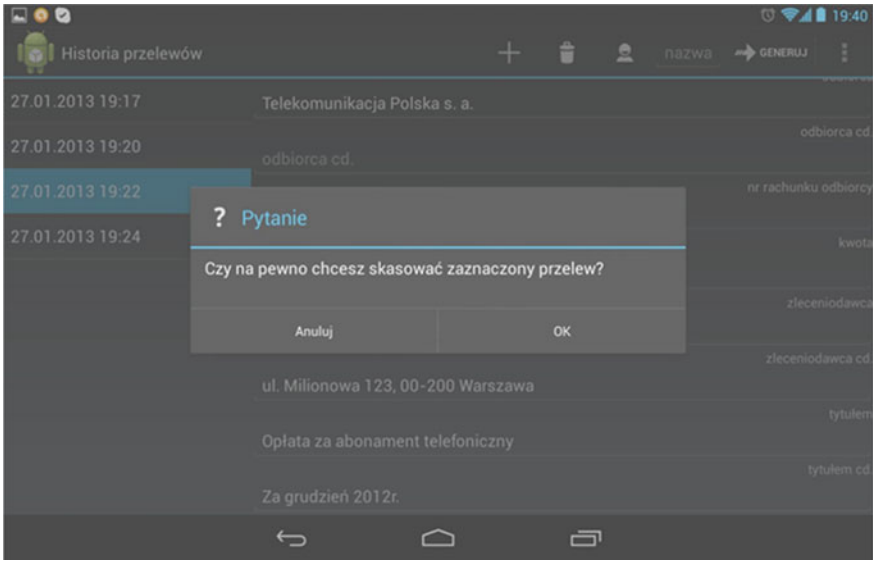

Fig. 31 Removing printing from the "transfer history" in the system application Android

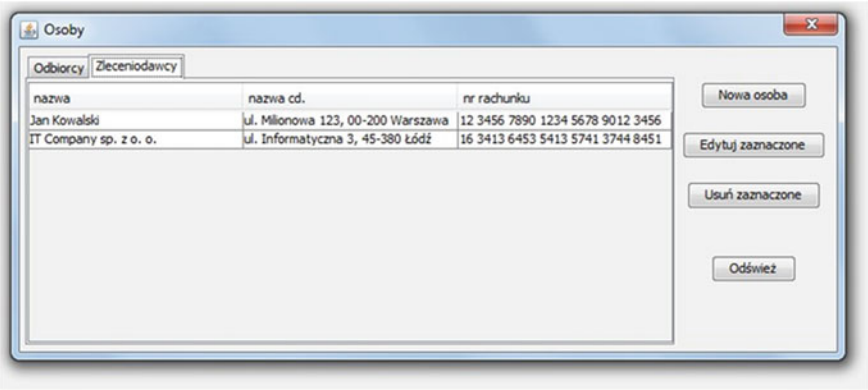

Fig. 32 Window for managing customers and customers in Microsoft windows program

5.7 Management of Customers and Reception

A program written for Microsoft Windows includes the ability to arzu- management of recipients and customers. This functionality has been abandoned in the Android program due to minimizing the actions that the user should take to properly use the program.

Nevertheless, it is possible to preview customers and recipients in the Android program. To do this, press the person icon in the menu bar (Fig. 19). The pre-section window in Fig. 25 (Subseap 5.3) will then be displayed.

In the Microsoft Windows program, you can add, edit, and remove both customers and recipients. To do this, press the People button in the main window of the program or in the Transfers menu (Figs. 18 and 22). When you press this button, the pane shown in Fig. 32 appears.

As you can see on the screen in Fig. 32, you can add, edit, and delete customers and recipients in this window. These steps are done by pressing the appropriate buttons.

When you press the New Person button, the window appears, as shown in Fig. 33. In this window, when you type the appropriate fields and press “OK”, the customer or recipient is added to the database. At this point, you can already use the newly added item to create a new or edit an existing print.

If you are editing an existing recipient or customer, please read it and press the appropriate button (Fig. 32). Then the window shown in Fig. 34 with the fields filled in accordingly will appear. Once the changes have been verified and approved by the “OK” button, that person’s data will be “overwritten” in the database.

To remove an existing customer or customer, select the customer and press the appropriate button (Fig. 32). A window will then appear asking you to confirm the deletion, which is shown in Fig. 35. When the "Yes" button is pressed, the selected recipient or requester is removed from the program and from the database.

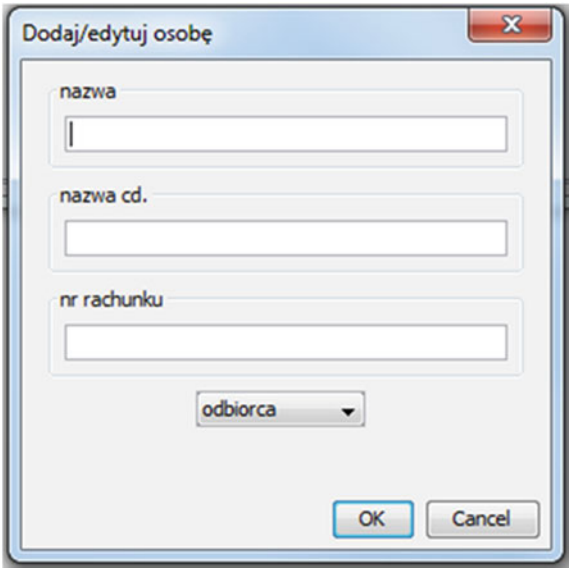

Fig. 33 Window for adding a new customer or requester in a Program for Microsoft Windows

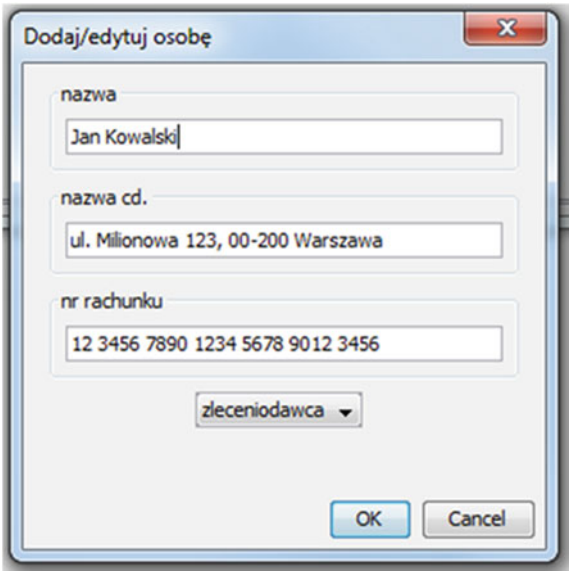

Fig. 34 A window that edits an existing customer or requester in a Program for Microsoft Windows

5.8 Configuration of Program Parameters

Both programs use two types of databases. The choice between them is determined by the user's preferences. If you are using programs on both supported platforms at the same time, select the PostgreSQL type database because this database is available

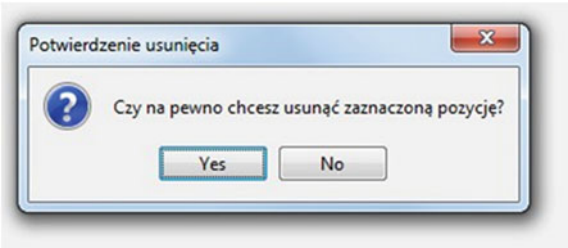

Fig. 35 Request confirmation by removed the recipient or customer in the Microsoft Windows program

remotely for both pro-grams. If you are using a Microsoft Windows-only application, select the SQLite database because it is easy to use and does not require your own server.

In addition to database support, these programs save the generated PDF in a specific path in memory. What's more, they run document browsers of this type. All of these variants can be manually configured by the user of each program.

To configure an application in Microsoft Windows, you must select the Options menu (Fig. 36) and Settings. The program settings window appears in Fig. 37.

As you can see in Fig. 37, in a Microsoft Windows program, you can set the path to a PDF that contains the generated prints and the path to the program that is the PDF document viewer. Additionally, you can use two databases that are switched between each other. In the SQLite section, you can set which file is a program database, while in the PostgreSQL section you can set the full client configuration of that database, which is the address, database name, database user, and password.

For an Android program, you can only configure the PostgreSQL database client. When a print file is generated, it is opened by the system, so there is no need to specify which program to run the file. The PDF document is permanently stored in the main catalytic log of the device's memory card. The screen that contains the settings window for this application shown in Fig. 38.

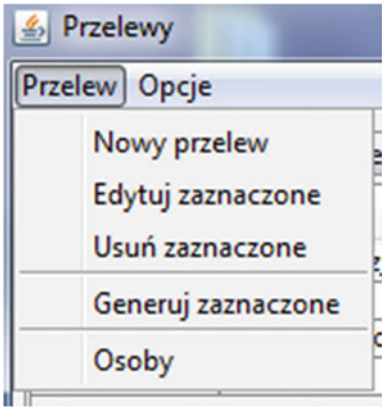

Fig. 36 In-App Options menu for Microsoft Windows

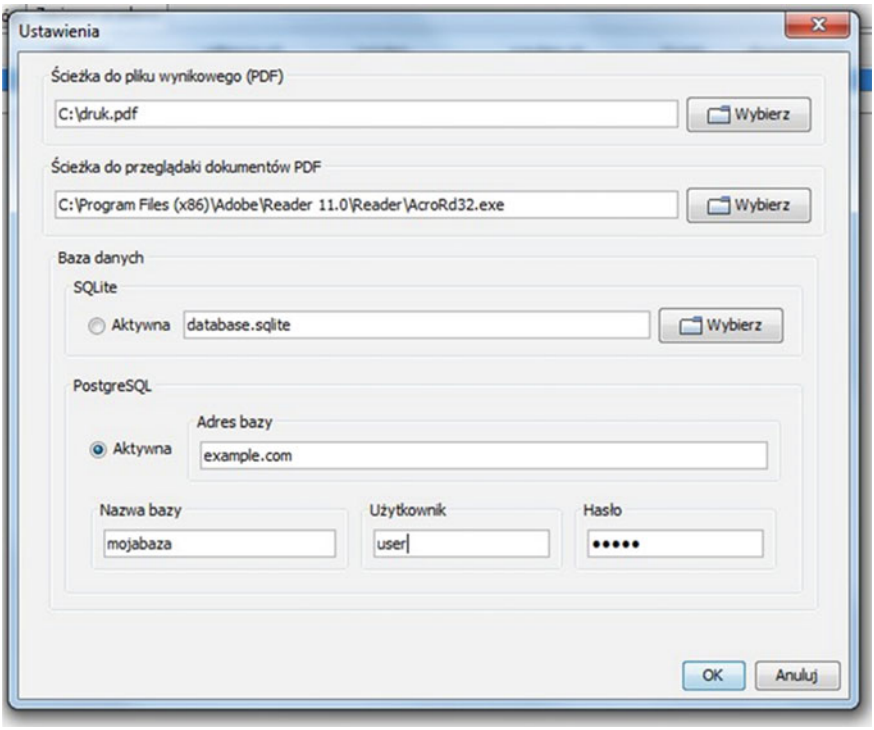

Fig. 37 Settings window in Microsoft windows app

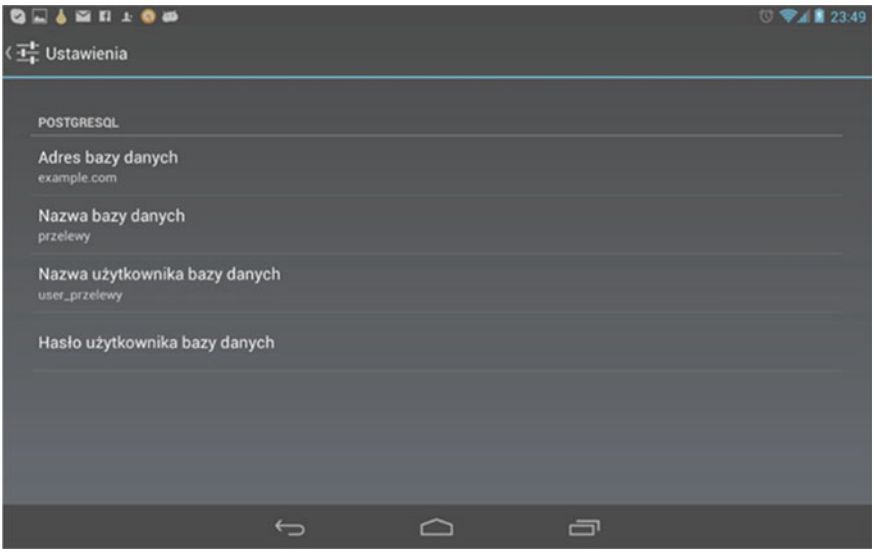

Fig. 38 Settings window in the Android app

Both created programs implement the same functionalities—the creation of wire transfer and prints for cash deposits. These prints are saved in PDF format and their data is stored in databases. Both applications are based on the simplicity and friendliness of the interface, which is intended to prevent the user from "handwritten" writing out prints. The appearance of the program for Android is very similar to the appearance of the program for Microsoft Windows, so that the simultaneous operation of both programs is very simple.

6 Conclusion

Created as part of the above thesis, the practical application for Android and Microsoft Windows and the preceding theoretical part solves the problem described in the introduction and explains the issues of cross-platform application. The presented method of creating cross-platform programs, resembles the construction of the model-view-countered pattern, which justifies comparing its theoretical structure with the structure of the created application.

Comparative analysis of Java and C++ languages in terms of their use in cross-platform applications has not clearly emerged as a better option. In terms of performance, C++ seems to be a better language because it's several times faster than Java [25].

The difficulties that can be encountered when writing cross-platform applications in this language move it to second place in terms of ease of use of these technologies. One of the biggest problems with using this language—calling different system functions for different platforms—solves Java. The resulting code for a Java-written program is used by a virtual machine that calls the appropriate system functions itself. So, the programmer doesn't have to work directly in the system rows. Due to the ease of use when creating cross-platform applications, Java was used for the practical part of this thesis.

Two applications, which are part of the design of the practical part of the perform the same functionalities. The first is the creation of overflow prints and cash deposit prints, which are saved in a PDF file. The second is to store the information contained in the prints in the databases. The appearance of both apps is similar to make them easier to use at the same time. The Program for Android, in connection with the program for Microsoft Windows, does not have a module that manages customers and customers and does not support the SQLite database. This is due to minimizing the actions that a user needs to take to use the app in order to use the app—this is the idea of creating mobile apps.

This work has prospects for further research and development in the day-to-day development of Software Engineering. One of them is the analysis and application of the security of connections between applications and databases. This is a very broad topic and, from the practical side, even necessary for realization, as data security is very important. Another direction of development of the work is the extension of the talk associated with the creation of PDF documents. In other words, it's about

analyzing ISO 32000-1 for application development. It is also worth considering the technique of dispersing the functionality and services of the application. Nowadays, this topic is very popular, and the same issue is very interesting. In this era of dominance of mobile platforms and services, it is very important to talk about the design of cross-platform applications. Existing tools provide it with a very large possibility of creating pro-grams of this type. Every programmer should know this topic perfectly and write applications so that they are portable on many hardware and system-speech platforms.

References

1. Hook, B.: Write portable code: an introduction to developing software for multiple platforms. Ed. 1. No Starch Press Inc. ISBN 1-59327-056-9, pp. 1–16, 19–23 (2005)
2. Eckel, B.: Thinking in Java. Fourth Edition. HELION Publishing House. ISBN 83-246-0111-2, pp. 161–164, 515–517, 867–905 (2006)
3. The Java Virtual Machine Specification, Java SE 7 Edition. Available on the Internet. http://docs.oracle.com/javase/specs/jvms/se7/jvms7.pdf, p. 2
4. Hundt, R.: Loop Recognition in C++/Java/Go/Scala [accessed January 2, 2013]. Google. Available on the Internet. https://days2011.scala-lang.org/sites/days2011/files/ws3-1-Hundt.pdf
5. Description of the Beep() method in the technical documentation of the Windows API program interface [accessed: January 13, 2013]. Microsoft. Available online. http://msdn.microsoft.com/en-us/library/windows/desktop/ms679277%28v=vs.85%29.aspx
6. Description of the printf() method in cstdio library reference [available: January 13, 2013]. Available online. http://www.cplusplus.com/reference/cstdio/printf/
7. Qt API Technical Documentation. Verseme 4.7. Available on the Internet. http://doc.qt.digia.com/4.7/index.html
8. Grybosz, J.: C++ Standard Symphony. Tom 1. Publishing house "EDITION 2000". ISBN 978-83-7366-134-4, pp. 255–259 (2008)
9. Zakrzewicz, M.: Designing J2EE applications in the Model-View-Controller architecture [accessed January 13, 2013]. Available on the Internet. http://www.cs.put.poznan.pl/mzakrzewicz/pubs/ploug05mvc.pdf
10. Description of the Model-View-Presenter design pattern [accessed: 14 January 2013]. Available online. http://msdn.microsoft.com/en-us/magazine/cc188690.aspx
11. Description of the Presentation-Abstraction-Control design pattern [accessed January 14, 2013]. Available online. http://trese.cs.utwente.nl/Docs/Courses/university_courses/patterns/material/oldstuff/presentation_abstraction_control.pdf
12. Android SDK Technical Documentation. Version 10 (API level 10). Online. http://developer.android.com/reference/
13. Description of the Android developer operating system [accessed January 14, 2013]. Available on the Internet. http://developer.android.com/about/index.html
14. Android Graphical User Interface Overview [Accessed: January 14, 2013]. Available on the Internet. http://developer.android.com/design/get-started/ui-overview.html
15. The Android Open Source Project (AOSP) [accessed: January 14, 2013]. To-next on the Internet. http://source.android.com/about/index.html
16. Android Compatibility Description [accessed January 14, 2013]. Internet access. http://source.android.com/compatibility/index.html
17. Description of the development tools for the Android operating system [until 14 January 2013]. Available on the Internet. http://developer.android.com/tools/index.html

18. Explanation of working with SQLite database on Android [accessed January 13, 2013]. Available online. http://developer.android.com/guide/topics/data/data-storage.html#db
19. Logcat technical specification [accessed January 13, 2013]. Available online. http://developer.android.com/tools/help/logcat.html
20. Lowagie, B.: iText in Action Second Edition. Manning Publications Co. ISBN 9781935182610, pp. 1–5, 8–21, 49–51 (2011)
21. Bauer, C., King, G.: Hibernate in Action. Manning Publications Co. ISBN 1932394-15-X, pp. 22–29 (2005)
22. ORMLite Technical Documentation. Version 4.42. Available on the Internet. http://ormlite.com/docs/ormlite.pdf
23. SQLite Technical Documentation. Available on the Internet. http://www.sqlite.org/docs.html
24. PostgreSQL TechnicalComment.: Version 9.2. Available on the Internet. http://www.postgresql.org/docs/9.2/interactive/index.html
25. The Java Language Specification, Java SE 7 Edition. Available in Interne. http://docs.oracle.com/javase/specs/jls/se7/jls7.pdf, p. 1

Challenges and Perspectives of the Legislative Solution to the Problem of the Plots of Land of Unidentified Owners in the Slovak Republic—Defining the Public Interest

Maroš Pavlovič and Matúš Michalovič

Abstract The scientific study focuses on the analysis of legislative possibilities in approaching the solution of a problem from the history, which, however, persists in the conditions of the Slovak Republic to this day—a relatively large amount of the plots of land whose legal owners are not known. Recently, there has been an attempt by the State to formulate a legislative solution in the form of a separate act that would provide a solution to this issue. By analyzing the identified shortcomings that have burdened the legislator's previous attempts to solve this problem, court decisions, and scientific literature it identifies individual obstacles inextricably linked with the plots of land of unidentified owners. Subsequently by using the methods of synthesis induction and deduction authors abstract the possible nature of some substantive as well as procedural legal institutes and provide solutions to them in the form of proposals *de lege ferenda* that are not only legal but also practical and beneficial for all stakeholders. Attention is paid primarily to defining the public interest in resolving the situation when almost a tenth of the territory of the Slovak Republic has undetected owners. Since the Act on the Plots of Land of Undetected Owners is still in a process of preparation, such a study has the potential to be helpful to its authors and to arouse the greater interest of the professional public in this issue.

1 Introduction

According to the annual report of the Slovak Land Fund, the plots of land of undetected owners covered up to 424,266 ha [1] in the year 2020, which is up to 8.65% of the total area of the territory of the Slovak Republic which is 4,903,405 ha [2]. This not inconsiderable part of the acreage causes significant problems manifested in the

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hampering of territorial development, rural development, and agricultural development, the construction of line structures (e.g. highways, railroads), effective environmental protection, or landscape design. The last-mentioned—landscape design and formation is particularly important when adaptation measures need to be taken to mitigate the adverse effects of climate change, allowing e.g. effective water retention in the country, preventing wind erosion or water erosion of the soil. It is therefore also important to resolve the question of what plots these measures will be implemented on. One of the possible options where this could be done and the land can be used for landscape formation aimed at mitigating the negative consequences of climate change and territorial development are the plots of land of undetected owners. Such plots of land are currently managed by the Slovak Land Fund, which the ability to manage such land, *de lege lata*, is considerably limited by the law [3]. The special regulation for the management of the plots of land with undetected ownership can be found in the second part of the Act of the National Council of the Slovak Republic no. 180/1995 Coll. on Certain Measures for Land Ownership Arrangements, as amended (hereinafter referred to as "Act no. 180/1995 Coll.").

Through this piece of legislation, the legislature has tried to resolve the issue of the plots of land of undetected owners. The issue of the plots of land of undetected owners should have been dealt with based on the provision of Section 15 of the Act no. 180/1995 Coll., which was later declared to be in non-compliance with the Constitution of the Slovak Republic by the finding of the Constitutional Court of the Slovak Republic (hereinafter referred to as "Constitutional Court") [4]. The reasoning of this finding was, *inter alia*, based on the fact that this provision contained an insufficient definition of the public interest in the transfer of ownership to the state, the "nationalization nature" of the provision not allowing individuals access to individualized objects of ownership rights. The main reason for this was that such a transfer of ownership should have taken place *ex lege* and *en bloc*. The additional identified shortcoming of this legislation was the absence of means of procedural defense in the event of a legal successor to the undetected owner would be identified and would like to exercise his property rights. However, in its decision, the Constitutional Court set limits and provides the legislator with "instructions" on how the approach the solving the issue of the plots of land of undetected owners can be approached in a constitutionally conformal way.

Based on the methods of analysis, synthesis, and deduction, the authors identify the public interest in dealing with the phenomenon of undetected ownership of plots of land and define the basic concepts and principles that should form an immanent part of the forthcoming legislation. With a reference to the positive and negative aspects, the contribution analyzes and discusses concerns and comments raised in the legislative process initiated and carried out so far by the Ministry of Agriculture and Rural Development of the Slovak Republic (hereinafter referred to as "Ministry of Agriculture").

2 Analysis of Legislative Development Section 15 of the Act no. 180/1995 Coll. With Emphasization on the Intention of the Legislator

The government bill was submitted to the proceedings of the National Council of the Slovak Republic in May 1995. Its submission was preceded by the adoption of a resolution of the Government of the Slovak Republic no. 896 of 23. November 1993, by which the government adopted the Concept of Land Ownership Arrangement in the Slovak Republic.

The initial motivation to adopt the Act no. 180/1995 Coll. was related to the poor state of the land ownership records and legal relations to them, which is stated also in the introduction to the general part of the explanatory memorandum to it: Part of the legal structure of land ownership is public records of the plots of land and legal relations with them. This register is of fundamental, often constitutional, the importance for the establishment and duration of legal relations and, in essence, for the legal existence of plots of land as a subject of property relations. In the period since the establishment of full individual land ownership in the territory of the Slovak Republic, this register was practically not carried out in completeness and complexity, on the contrary, its completeness and perfection were weakened by various historically conditional disruptive influences until it eventually ceased to be kept altogether for a certain period of time [5]. The legislature intends to try to deal with the historical legacy of poor land ownership records, as significant part of this Act concerns the regulation of the way certain land is handled by the Slovak Land Fund, which is a legal entity (non-governmental and non-profit organization) that acts in the public interest. In particular, the Slovak Land Fund should have legal limits within which it may exercise ownership or management powers over the plots of land of which the owner is known but whose place of residence or registered office is unknown or plots of land whose owner is unknown.

According to Section 13 of Act no. 180/1995 Coll., these two types of plots of land are referred to by the legislative abbreviation "plot of land with undetected owner" which means that the state also considers undetected as undetected owners those owners who are known but their permanent residence or registered office or date of birth is unknown, but also owners who are not known at all.

The ambition to deal with the plots of land of undetected owners stems from the second part of Act no. 180/1995 Coll. and is regulated in Section 15. The government's proposal formulated the following wording of the provision of Section 15: The expiry of a period of three years from the entry of a plot of land with undetected ownership in the land register, but at the latest on the expiry of a period of five years from the entry into force of this Law, such plot of land is considered an abandoned object and these plots of lands are transferred to state ownership under the administration of the Slovak Land Fund. On such a legal construct, the submitter of the Act states in a separate section of the explanatory memorandum: The establishment of the register of renewed land registration is also a basis for unknown (undetected) owners to take steps to prove their ownership by standard procedure within the specified

period. If this is not the case, the law provides for the allocation of such plots of land to the State for such cases. It is a special regulation on the general regulation of the acquisition of ownership of things abandoned and things whose owner is unknown. At the same time, this Act should allowed owners to prove their ownership rights within 10 years of the Act's entry into force, which correlates with the period for the adverse possession of the real estate. From this, it can be concluded that the legislator approached the interpretation of the institute of abandoned subject and the institute of perseverance based on Act no. 180/1995 Coll., which in this case has the nature of a lex specialis.

In the context of the management of these plots of land, it is legitimate, in our view, to expect that, where the owners are not interested in their ownership, they do not exercise their ownership rights and do not fulfil their ownership obligations there must be a moment when the ownership rights pass from the undetected owners to the administrator of the managed plots of land. In particular, where the omission of obligations such as due diligence on agricultural plots of land leads to a threat in the text of the demonstrated public interest.

In the case of the government's proposed wording, the provision in question has been redefined in the legislative process. There were several proposals for change. Finally, the proposal of the Constitutional Law Committee of the National Council of the Slovak Republic was approved. This provision deals with the legislative term the undetected owner. The provision predicted that the plots land of the owners, who are known but their residence or registered office but also land, the owner of which is unknown. The provision predicted that not only plots of land whose owner is not known, but also plots of land of owners who are known but their residence or the seat are not known will become the property of the state. However, we can deduce this fact only on the basis of the legislative term of the plot of land of unidentified owners regulated in Section 13 of this act.

Subsequently, Section 15 has been modified by the adoption of Act No. 80/1998 Coll. This amendment of the provision was carried out in the legislative process initiated by the proposal of a group of Members of the National Council of the Slovak Republic. The parliamentary motion, which dealt with the organisation of relations between the Slovak Land Fund and state-owned enterprises in the field of forestry and water management, did not contain a provision adopted by parliament. The proposal of a group of Members has been amended in the legislative process. It is clear from Art. IV. point 4 of the joint report of the committees of the National Council of the Slovak Republic on the discussion of the proposals of the group of members of the parliament resulted in a change on the basis of which, at the end of Section 15 par. 1 the following wording was added: "…by the words or the State Forestry Organization in the case of plots of land which is part of a forest land fund and which is not part of a common property". In the explanation of the proposed change in the joint administration, the legislator stated: This change is required by the modification of the provision according to which plots of land of undetected ownership become state-owned after the expiration of the statutory period. In the case of forest land, they will be managed by a forestry organization [6]. A more significant and significantly more significant change to Section 15 occurred with

the adoption of Act no. 219/2000 Coll., which was even adopted in the shortened legislative procedure. The amendment to the provision concerned both paragraphs and consisted in replacing the determination of the temporal aspect of the provision, which provided for a five-year period for carrying out the proceedings for the renewal of the registration of certain plots of land and legal relations with them, for a period of ten years. The deadline was set explicitly for 1 September 2005. In this context, the legislator stated: However, given that the allocated budget in the past period did not meet the organizational arrangements and the integration of the state administration are facts on the basis of to be implemented within a five-year period and should therefore be extended to 10 years [7].

The last modification of Section 15 was implemented through Act no. 503/2003 Coll. on the Return of Ownership of Plots of land and on the Amendment of the Act of the National Council of the Slovak Republic no. 180/1995 Coll. on certain measures for the organization of land ownership, as amended. It consisted of adding new paragraphs 2 to 5. The original government bill contained an extension of only two new paragraphs. The fifth paragraph has been added as part of the legislative process. As part of this amendment to Act no. 503/2003 Coll. on the Return of Ownership of Plots of Land, which primarily regulates the return of ownership of plots of land, the amendment to Section 15 of Act no. 180/1995 Coll. was also adopted [8]. With the hindsight of the time, this appears not to be entirely related to the content of this Act and such extension was not even sufficiently justified by the legislator.

This represents the last change in the provision of Section 15 by the legislator. Subsequently, the provision was repealed on the basis of the decision-making activity of the Constitutional Court. The finding of the Constitutional Court of the Slovak Republic was published in the Collection of Laws under number 537/2006 Coll.

3 Act on the Plots of Land of Undetected Owners

According to Act no. 400/2015 Coll. on Lawmaking and on the Collection of Laws of the Slovak Republic and on amendments to certain acts, as amended, prior to the start of drafting a legal regulation, in the interest of informing the public and public administration bodies, the submitter shall publish preliminary information on the draft legal regulation being prepared. In the preliminary information, the submitter shall, in particular, briefly state the basic objectives and thesis of the forthcoming draft legislation, an assessment of the current situation, and the expected date of the initiation of the comment procedure. The inclusion of preliminary information in the legislative process can therefore be seen as an "invitation" of the submitter of the legislative process for stakeholders, in which it provides brief information on the forthcoming draft legislation. Preliminary information cannot be challenged for its superficiality, ambiguity, and inadequacy as its only legal feature is its brevity [9]. The Ministry of Agriculture also proceeded in accordance with this act and on 12 May 2022 published the Preliminary information that it is preparing the **Act on the Plots of Land of Undetected Owners** [10] as the first step in a long and complicated

legislative process. The advantage of such a process is that individual entities can send their comments within the set deadline and thus influence the drafting of legislation in its initial stage.

Five entities participated in the comment procedure on this preliminary information, namely Bratislava—the capital city of the Slovak Republic; and four of the interest associations operating in the Slovak Republic—the Slovak Agricultural and Food Chamber, the Association of Employers' Associations, Associations of the Slovak Republic, Club 500, and the Republic Union of Employers of the Slovak Republic. Therefore, the publication of the preliminary information met the intended objective although only partially. Despite the relatively low number of actors involved, it can be assessed that the comments provided contain several rational arguments and considerations that will need to be taken into account when preparing the exact wording of the Act.

3.1 The Basic Objective of the Act on Plots of Land of Undetected Owners and a Brief Description of the Proceedings Under This Act

The basic objective identified by the submitter in the preliminary information is to solve a long-term problem in the registration of ownership of land caused by the plots of land of undetected owners. The Act should regulate the procedure resulting in the transfer of ownership rights to the plots of land of undetected owners to the State [10]. It should be noted that the transfer of rights to the plots of land of undetected owners to the State should be the last of the objectives that the forthcoming legislation should fulfill. As a matter of priority, it will be necessary to find the largest possible range of existing owners and their successors in the title so that any transfer of ownership of the plots of land to the State does not extinguish their ownership right of such plots of land.

However, the proposed procedure also envisages the right to raise a claim by existing, but as yet undetected, owners and provides for sufficient time for any successors in title of the undetected owners to exercise their property rights once the claim has been established [10]. The question remains what time frame can be considered sufficient. The standard time limits associated with the general administrative procedure in the Slovak Republic (15 and 30 days, or an extension of another 30 days) are insufficient due to the complexity of the individual land ownership survey by the potential owners. In the authors' opinion, the time limits should be from a couple of months to years, while they consider **one-year period to be the most appropriate time frame**, which will start to run on the fifteenth day after the publication of the public notice. It is only after this period that the administrative authority should start issuing decisions in the proceedings in question. However, the proposed time limit represents the period in which a claim can be made, but the administrative proceedings may subsequently take longer.

The delivery of a set of plots of land with the undetected owner, which will contain all available data on the plot of land in question and joint ownership interests in the form of a public notice, is also foreseen by the submitter in the preliminary information. In view of the fact that the proposed procedure concerns unknown owners hence none or at least one of the participants in the proceedings are not known, it is not possible to deliver the necessary information in any other way than by public notice. Code of Administrative Procedure in Section 26 para. 1 defines three situations where it is possible to serve by public notice—cases where parties themselves or their residence are unknown or if so required by special legislation [11].

It is the subsidiary scope of the Code of Administrative Procedure that should constitute a guarantee in the form of a standard administrative procedure, which in the Slovak Republic is carried out continuously since the change of the state establishment in 1989, which led to the strengthening of private ownership rights. The application of the Code of Administrative Procedure increases legal certainty and guarantees the application of the general principles of administrative procedure in the proceedings in question. However, a specific procedure on the plots of land of undetected owners will also require specific principles and/or specific procedural regulations, which we addressed later in this contribution.

The responsibility of compiling the set of plots of land with the undetected owner is proposed by the Ministry of Agriculture to the district offices (which carry out state administration on the local level), more precisely to the departments of land and forest in cooperation with the land registry departments. Since the proceedings concern land and the registration of legal relations to them, the substantive and procedural jurisdiction of these public authorities is determined logically correctly. The land law agenda and management of land also require more personal knowledge of local circumstances to carry out an effective administrative procedure with the results required by the legislation. Therefore, those procedures should be carried out by local government authorities. However, the jurisdiction has been a controversial topic in public discourse as to whether the land law agenda should be managed through general local government bodies or specialised local government. From the standpoint of the authors, the best possible solution seems to be the creation of one specialised state administration body at the central level and several state administration bodies on the local levels, which would not only carry out such proceedings but would take over the entire land law agenda. Her closest partner in the state administration would be the land registry authorities [12].

The territorial district for the proceedings on the plots of land of undetected owners will be the cadastral territory or several cadastral territories in the territory of one municipality. The role of the municipality in this procedure will be significant, as is the case of the land consolidation procedure [13]. The municipality should participate in the fulfilment of the tasks of the Commission of Inquiry, whose tasks will consist in finding owners of land and/or legal successors of undetected owners and approving a plan for the implementation of joint facilities and measures. The plan for the implementation of joint facilities and measures should be recovered for the territorial district of the municipality and should be focused on the extra-urban area,

therefore it should be developed in cooperation with the National Agricultural and Food Center which provides for comprehensive research and knowledge gathering in the area of sustainable use and protection of natural, in particular soil resources and water, for plant cultivation and livestock raising, ensuring the quality, safety, innovation and competitiveness of food and non-food products of agricultural origin, the productive and extra-production impact of agriculture on the environment and rural development, and the transfer of knowledge of agricultural research to users [14]. This concept is elaborated in more detail below, in the part where the public interest in proceedings under the Act on Land of Undetected Owners is described.

3.2 Subject-Matter of the Proceedings Concerning the Plots of Land of Undetected Owners and the Legal Definition of Certain Terms

As the proposed proceedings on plots of land of undetected owners should be a matter of determination of the ownership of such a land, the subject of the proceedings should be any co-ownership right of the plot of land of which the owner is known but whose place of residence or registered office is unknown [15] and the land of which the owner is unknown [16]. Despite the fact, that the term "plot of land of the undetected owner" is used in different variations in numerous pieces of legislation, the legal order of the Slovak Republic does not contain its legal definition. This will be one of the tasks of the new act—to remove the inconsistency of this concept.

After the publication of the sets of plots of land with the undetected owners (as described above) and after the expiry of the set time limit these plots of land will be divided into two groups. The first group will consist of plots of land for which no claim of legal successors of undetected owners has been made [10]. In our opinion, in order to increase the principle of legal certainty, such plots of land should be legally defined under the special term "**unclaimed plots of land**" which definition could read as follows "plots of land not claimed by the participants in the proceedings on lands of unidentified owners under this Act".

This first group of plots of land should go through a special administrative procedure which will result in the issue of a series of first instance decisions linked to individualised joint ownership shares. Based on these individualised and reviewable decisions, ownership of the plots of land will be transferred to the State or, where appropriate, to other entities on the premise that such plots of land should remain in the public domain. That means owned by the State or the subjects of the territorial self-government. Hundreds of decisions will thus be issued at the end of the land procedure of the unclaimed plots of land and each of them will be individually reviewable. The list of such plots of land transferred to the State must be made publicly available in such a way that it can be consulted at any time e.g. in the event of a need for a retrial or in the event of the need for a judicial review of the decision.

We are of the opinion that the ownership of plots of land that are located in the municipalities' inner lines should be primarily transferred to the municipalities. If some of these plots of land are needed for a self-governing region, these could be transferred by mutual agreement (between a municipality and a self-governing region) to the self-governing region. **It is essential that they will be publicly owned and will serve a public purpose.** However, it will be also necessary to deal with small shares, not exceeding the area, which will be determined on the basis of a thorough analysis, of all the joint ownership interests in the plots of land of the undetected owners. Such negligible ownership shares could also be transferred to private entities, but with priority given to those who manage the plots of land in question or to entities that are interested in settling ownership of agricultural farms.

The second group of plots of land will be the subject to a separate land procedure with a claim will be consisting of plots of land of undetected owners, to which the successor of the undetected owner's right of title to the plot of land in question or the joint ownership interest has been claimed. A person who claims to be entitled to ownership of the plot of land of the undetected owner will be under obligation to prove this claim in proceeding to which he will be a party until proven otherwise. From the point of view of the legal definition, such land could be designated as "**claimed plots of land**" and therefore plots of land to which the participants in the proceedings under this Act have filed a claim.

3.3 Raising a Claim to a Plot of Land of the Undetected Owner and Legal Remedies

The process of raising a claim must be strictly and clearly defined by law, preferably by the future Act on the Plots of Land of Undetected Owners. The basic requirement that must be regulated is the legal method that enshrines how such a claim can be proved. Witness statements, solemn statements, etc. should be excluded from these methods. The procedure should be based primarily on data and information from the land register, from the register of residents of the Slovak Republic, from various records of tenants of land, land associations, and other authorized persons, on documentary evidence, and, e.g. on professional genealogical analyses. In such proceedings, there should not be a doubt as to the claim made. In case of doubt, the administrative authority should decide in favour of public ownership, thus transfer the ownership of the plot of land to the State or other eligible subject.

However, the party to the proceedings will have a series of remedies available to him. The first instance decision should be made by the department of land and forestry of the district office with territorial jurisdiction. In the case of a proper appeal, the district office in the seat of the region, the department of appeals, will be competent to decide on it. In the case of transformation into a specialised state administration, the district land office shall issue first-instance decisions and at the second stage, the central land office shall decide on the first instance and at the second

stage, the land office is the competent authority. The appeal procedure should be based on the principles of general administrative procedure contained in the Code of the Administrative Procedure. The only exceptions are the time limits for bringing appeals that could be modified, i.e. extended in favour of a party to the proceedings. The adoption of such legislation will ensure compliance with the principle of duality in administrative proceedings which is the basic legal principle of administrative law in the Slovak Republic.

In the event of dissatisfaction with the decision issued in the administrative proceeding, the party to the proceeding still has the opportunity to submit his claim in the court proceedings through administrative action, thus ensuring that the decision of the administrative body is reviewed at two other possible levels of courts. Since ownership enjoys significant constitutional protection, the disputed matter can also be considered in exceptional cases by the Constitutional Court or the European Court of Human Rights. In the proceedings, therefore, the participant will have sufficient procedural defence options, which will (potentially) allow him to review the decisions at another five levels within not only the executive branch but also the judicial branch of the government. This significantly improves the quality of decision-making on the contested ownership of the plots of land and it should eliminate the possibilities of unlawful situations concerning property rights to plots of land. This shortcoming of previous attempts to solve the issue of the plots of land of undetected owners through Section 15 of Act no. 180/1995 Coll. was also identified in the finding of the Constitutional Court, which states that these transitions of ownership are not reviewable, or the law does not presuppose their review in a manner customary in the rule of law, for example in the administrative judiciary [4].

3.4 Return of Undetected Owner's Plot of Land to the Rightful Owner and Determining the Value of the Plots of Land to Create a Guarantee Fund

If the claim of the party to the proceedings is proved, the State will be obliged to hand over the plots of land or provide adequate compensation to the successful party of such proceedings. In the context of appropriate compensation, the application of a defined public interest should be used. For example, if there is a public building located on a given plot of land, the ownership of that plot of land should be transferred to the entity to which the public building belongs. Or, in the case, if the realization in the public interest is planned on the plots of land (e.g. the construction of the hospital, the realization of joint facilities and measures, line constructions, etc.), compensation should be issued to the successful party. The type and amount of such compensation should be based on the principles of Section 4 of Act no. 282/2015 Coll. on Expropriation of Land and Buildings and on the Enforcement of Restrictions on the Right to Property, as amended (hereinafter referred to as the "Expropriation Act"). Compensation should therefore be provided primarily in cash, provided that,

as long as it is possible to provide compensation by allocating different plots of land and the party in question agrees, this method of the settlement will take precedence over settlement in cash.

Compensation should therefore be provided primarily in cash, provided that, as long as it is possible to provide compensation by allocating replacement land and the party to the agreement agrees, this method of the settlement will take precedence over settlement in cash. In this context, the question of determining the value of plots of land also arises, which in our opinion, should be subject to expert assessment in specific cases.

The expert assessment of the plot of land will have to be carried out separately and will be the basis for the issue of compensation or, where appropriate, the transfer of the plot of land to the beneficiaries. The value of all the plot land to be the subject of the proceedings, which will be determined on the basis of an expert assessment, should be the value by which the guarantee fund, serving to satisfy the claims subsequently awarded, should be gradually increased. The guarantee fund should be made up of income from these plots of land consisting primarily in their lease or in the necessary cases legally regulated divestitures. The income of this fund would also be made up from the fees of private individuals who would pay to settle negligible shares to their advantage.

The funds in the guarantee fund would be set for a special purpose and blocked for 10 years. The period of 10 years is be indicated in the abovementioned preliminary information: In order to mitigate the intensity of the interference with the ownership right, the procedure may be resumed within 10 years from the date of the decision on the plots of land in the first group (unclaimed plots of land). Despite the legitimate objections based on to the imprescriptible character of ownership rights it will be necessary to set a time limit that preserves the ownership structure of a certain foreseeable quality. Such a time limit could be identical to the time limit expressed in Act no. 40/1964 Coll. The Civil Code, as amended, which, inter alia, regulates the time limit for adverse possession in the legal order of the Slovak Republic, which is 10 years when it comes to real estate. To this end, Fečík [17] states the following: The subject of the adverse possession may also be the joint ownership interest. If the subject of the adverse possession is agricultural land or forest land outside the built-up area of the municipality or the joint ownership interest in it, it is not subject to restrictions on the prohibition of crumbling resulting from the third part of the Act of the National Council of the Slovak Republic no. 180/1995 Coll. on Certain Measures for Land Ownership Arrangements, as amended [18]. The adverse possession does not have the nature of a legal act, but rather a specific legal fact through which ownership is acquired. Even in the case of decisions issued in proceedings on the plots of land of undetected owners, this is not a legal act but rather a specific legal fact establishing the ownership right of the State or other qualified entities. In this example, it can be seen how the specific object of property is land and, in particular, agricultural and forest land with production and non-production functions, especially the upper layer which consists of soil – one of the components of the environment. It will therefore not be possible to view this procedure strictly by the optics of public

or private law. For the multidisciplinary of a regulated issue, it will be necessary to strike a balance between the public interest and the private interest.

3.5 Public Interest in the Adoption and Application of the Act on Plots of Land of Undetected Owners

Given the vagueness of the concept of the public interest and the legal practice in its application, it can be concluded that the determination of what is in the public interest belongs to the State, which, however, is bound by legal limits in its assessment. In this context, we would like to make a reference to the finding of the Constitutional Court according to which the concept of public interest is legally demarcatable only in relation to a particular fundamental right or freedom. If the purpose intended by limiting the right to property cannot be achieved by means which extend more leniently to the constitutionally protected right of property, and if the public interest is superior and objectified to the interests of the owner, the condition of the public interest may be deemed as fulfilled [19].

The European Court of Human Rights also leaves broad autonomy for the determination of the public interest to the states, which, in its ruling James and others v United Kingdom found that the concept of public interest is necessarily extensive …the Court, finding it natural that the margin of appreciation available to the legislature in implementing social and economic policies should be a wide one, will respect the legislature's judgment as to what is "in the public interest" unless that judgment be manifest without reasonable foundation [20].

The primary role of the State in limiting the property rights of undetected owners in the context of Article 20 para. 4 of the Constitution of the Slovak Republic [21] will consist in the obligation to sufficiently define the public interest in such proceedings. In the context of cited court decisions relating to the public interest, it could be concluded that there are several options available. The nature of the land—as a limited economic good with both productive and non-productive functions needs to be taken into account while defining the public interest.

In defining the public interest, we must take into account the nature of the land—as a limited economic good with both productive and non-productive functions.

4 Draft Preamble to the Act on the Plots of Land of Undetected Owners

As one of the viable options for defining naming the public interest, which could also bear a symbolic link to Act no. 229/1991 Coll. on the Regulation of Ownership Relations to Land and other Agricultural Property, as amended (hereinafter "Act no. 229/1991 Coll.") there appears to be the utilization, in the legislative conditions of

the Slovak Republic, unusual, an element of legal regulation—the preamble to an act.

It is Act no. 229/1991 Coll., which represents the cornerstone of modern land law in the Slovak Republic, which contains a preamble, the universality of which is applicable to a number of acts. This preamble makes it possible to abstract the basic principles of land law by giving legislation governing relations to a specific object—land a specific characteristic, which in the theory is one of the basic defining features of land law. The preamble of the future act should be drafted in such a way that covers both public and private aspects and it should be possible to derive from it the basic principles of the procedure on the plots of land of undetected owners and to establish the basic principles of proceedings on the plots of land of undetected owners. The preamble could read as follows:

The National Council of the Slovak Republic, in an effort to.

- effective management of the **territory of the Slovak Republic** consisting in the rational use of the production and non-production functions of the land,
- deal with obstacles caused by the plots of land of undetected owners in both the public and private spheres,
- adjust ownership relationships to the plots of land of undetected owners in accordance with the interests of all owners, the maintenance of food security, economic rural development, and in accordance with the requirements for land creation and the environmental protection has adopted the following Act:…

In the following part, we analyze the individual provisions of the preamble proposed by us.

4.1 Effective Management of the Territory of the Slovak Republic

The introductory point of the preamble referring to the **effective administration of the territory of the Slovak Republic** works with the concept of the territory of the Slovak Republic in a targeted manner, as this concept is established by Article 3 of the Constitution of the Slovak Republic, which stipulates that the Territory of the Slovak Republic is unified and indivisible.

Professor J. Kľučka states that the territory of the State is separated by national borders from the territory of another (other) States or the territories that are not subject to the sovereign power of any State. National borders, therefore, define (delimit) that part of the earth's surface over which the State exercises its sovereign power [22]. It is the reference to the sovereign exercise of the sovereign power of the state in its territory, limited by freedom and equality in dignity and rights, that creates one of the preconditions for the constitutionality of proceedings on the plots of land of undetected owners. Rational land use is currently hampered primarily by fragmentation and insufficient land ownership records. In connection with the rational

use of land, several considerations arise which could result in the adoption of several institutes streamlining the approach to land management.

The future act should link up at least three proceedings that are directly related—the procedure for drawing up a plan for the implementation of joint facilities and measures, the procedure for the plots of land of undetected owners, and the land consolidation procedure. As the first procedure in a row, the procedure for drawing up a plan for the implementation of joint facilities and measures, which should be regulated in the Act of the Plots of Land of Undetected Owners. This plan should be used to assess the creditworthiness of the plot land, identify sites suitable for the implementation of joint facilities and measures and determine the area that will need to be used for their implementation. It should also include an expert estimate of the price of undetected landowners based on zoning. In the case of drawing up a plan, this will be the phase that precedes the publication of the set of plots with the undetected owners. The plan should be drawn up at the initiative of a district office, the Department of the Land and Forestry Department in cooperation with the municipality, the self-governing region, the co-owners of the affected plots of land, the tenants of the plots of land, and the Slovak Land Fund or the land manager.

It seems to us to be the most suitable proposal that the plans be drawn up through the professional capacities of the National Agricultural and Food Center, which should lead to the strengthening of pedological and landscape capacities. This should result in the renewal of the importance of pedology in agriculture and could follow the legacy of Professor Juraj Hrašek, who is one of the founders of pedological research in the Slovak Republic. Máčaj also describes the possible role of land management in the context of the land consolidation procedure, with which we propose to link the procedure of the plots of land of undetected owners, who notes that if the aim of land consolidations was landscaping that would take into account multiple interests—both in landscaping or other legal relations to land, as well as issues of ecological stability of the territory, the requirements of pedology must be taken into account when preparing a land consolidation projects [23].

In the context of the tasks of the National Agricultural and Food Center, under which the Research Institute of Soil Science and Soil Protection falls under, it was pointed out that role should be precisely linked to the construction of public and joint facilities and measures in the country. In their construction in the future, it is the public interest that is increasingly coming to the fore, in its broadest possible importance, not only with regard to the owners of the plots of land in question or the inhabitants of the municipality of the territory in question but also the public interest in the protection of agricultural land or forest land [23].

The introductory point of the proposed preamble also works with concepts such as the production and non-production functions of the land. In the context of the production functions of the land, priority is on the agricultural land [24] and the forest land [25]. The production functions of the land are primarily based on the production of economic goods, such as food or wood. In defining the non-production functions of land the legislation is in the Act no. 326/2005 Coll. on Forests, as amended, which defines these functions as ecological functions, which are agricultural protection, water and climate function, and social functions, which are mainly health, cultural,

educational, recreational, natural conservation and water conservation functions [26]. Thus, when it comes to the production and non-production functions of the land, the public interest is in this case obvious. Given the fact that this procedure may affect a number of rights and the legitimate interests of the persons concerned, it will be necessary to find a balance between the protection of both functions.

The fundamental legal fact that will have to be dealt with is also sufficient reasoning as to why the rational use of land is not regulated in existing legislation but requires further special regulation, which logically entails the risk of complicating the land law system. The Constitutional Court admits such mutual "competition" of several legislations. For example, in its finding no. PL. ÚS 20/2014 from 14. November 2004, it did not rule out the possibility for the legislator to pursue the same objective with two different pieces of legislation. However, it presupposes their sufficient justification, pointing out the differences between them. In our case, there could be a situation where the Constitutional Court would have to assess the fact that for the realization of the same interest, for example, the realization of joint facilities and measures, there is an expropriation institute and this new act would create a new way of acquiring land into state ownership realized based on the procedure on plots of land of undetected owners. The Act on Plots of Land of Undetected Owners also has the potential to compete with the Expropriation Act. That is why the standards of this law should be the subject of discussion, particularly when it comes to setting clear conditions of the expropriation. According to Section 2 para. 1 of the Expropriation Act, expropriation may be carried out only:

(a) to the **extent necessary**,
(b) in the **public interest** for the purpose laid down by law, the public interest in expropriation being demonstrated in expropriation proceeding,
(c) for **adequate compensation**, and
(d) where the objective of expropriation cannot be achieved by agreement or otherwise.

We conclude that the first criterium—necessary extent can be proved in the context of the procedure for the plots of land of undetected owners. However, this procedure must take place publicly, in the form of an intensive information campaign, and within the framework of intensive cooperation between stakeholders. The purpose of this procedure must be, as a matter of priority, to return the plots of land to the rightful owners or their successors in title to whom it belongs. Only those plots of land for which ownership is not established legitimately should be transferred to state ownership or other forms of public ownership. The act must set clear limits eliminating the possibilities for corruption and should not create conditions within which the plots of land of undetected owners without proven ownership will become subject to the opaque interest of various entities. It must therefore be made clear how these lands can be handled, with their disposal being taken as a last resort, which could be preceded by e.g. exchange on demonstrably mutually beneficial terms and on demonstrating the public significance of the transaction.

Among other things, the basis of plots of land that will become the public ownership will also serve to create a guarantee fund for compensation purposes for owners

who will exercise their right of ownership after the procedure on plots of land of undetected owners. It is therefore assumed that these plots of land will be leased out to the entities which will manage them. The proceeds from these plots of land will thus serve to compensate for any harm to potential owners and the State will maintain a tool for the effective management of public land ownership, the reform of which must be an essential part of the proposed act. Thus, the State will be able to support specialised production, small and medium-sized farmers, will be able to contribute to the implementation of the intentions of large farms, will be able to support infrastructure and economically important projects, to settle land in protected zones, etc. However, the management of public land ownership must be based on the premise that **public land ownership can only be used in the public interest.**

This procedure must also entail secondary effects—it shall lead, for example, to raising awareness of the importance of land ownership, but also of the rights and the obligations associated with land ownership. Citizens and potential parties to proceedings must be aware of the significance of provision in the Constitution of the Slovak Republic, more precisely in the first sentence of Article 20 para. 3, according to which the ownership is binding, but also the importance of the Roman-legal principle of *vigilantibus iura scripta sunt* (the laws serve the vigilant). Therefore, from the point of view of the general methods used in public administration, the persuasion method implemented in the form of a campaign highlighting also the negative consequences of inaction from the point of view of the owner will play a crucial role.

4.2 Dealing with Obstacles Caused by Plots of Land of Undetected Owners in the Public and Private Spheres

The public interest in proceedings on the plots of land of undetected owners assessed in the context of the Expropriation Act can be demonstrated in hundreds of proceedings in which the plots of land of undetected owners create complications. These proceedings concern ordinary civil claims, but also significant infrastructure projects of major importance, which cannot be foreseen in the future. The current situation *de lega lata* is therefore an obstacle that needs to be removed in order to make the exercise of land ownership and obligations more efficient.

The Constitution of the Slovak Republic and the Expropriation Act both established **adequate compensation** as one of the conditions of expropriation or forced restriction of property rights. The price determined by the expert opinion at the time when the undetected owner's rights were transferred to the State can be considered as appropriate compensation expressed in money. However, in the spirit of the expropriation law, we consider the issue of the original plot of land or replacement of it to be a more appropriate substitute for a similar value in the locality in which the original plot of land was located. As described previously, the sum of the value of all the plots of land that would have been transferred to the State in the proceedings or

would have served a public interest purpose would form the basis of the guarantee fund for the cadastral territory in question.

The last qualitative category—**the objective of expropriation cannot be achieved by agreement or otherwise** is fulfilled by the very substance of the procedure for the plots of land of the undetected owners since an agreement with the undetected owner is virtually impossible. In the diction of part of the provision or in any other way we can identify the underlying argument when pointing out differences between expropriation proceedings, under the Expropriation Act and expropriation proceedings under the Act on Plots of Land of Undetected Owners.

The procedure shall aim to find the original owners and their legal successors as a matter of priority. However, the proceedings will not only be carried out for the benefit of (undetected) landowners, but also for the benefit of known landowners in the form of removing obstacles that the plots of land of undetected owners create in several other potential proceedings.

4.3 Adjustment of Ownership of the Plots of Land of Undetected Owners Following the Interests of Owners, Maintaining the Food Security, Economic Rural Development, and Following Land Creation and Environmental Protection Requirements

The third point of the proposed preamble aims to adjust ownership relationships to the plots of land of undetected owners in accordance with the interests of all owners, the maintenance of food security, economic rural development, and in accordance with the requirements for land creation and the environmental protection and relies mainly on the non-productive functions of the land. We would like to point out again, however, that in the first place it follows the interest of the owner, which should be one of the basic principles of the procedure. The state in the proceedings may not use its public power to acquire rights to the plots of land of undetected owners at the expense of potential owners who will actively defend their rights. If the number of owners is exhausted and all legally and legitimately satisfactory claims are satisfied, the state shall transform the remaining land into its ownership to remove obstacles in future proceedings.

The concept of food safety was incorporated into the Constitution of the Slovak Republic based on the adoption of the Constitutional Act no. 137/2017 Coll. Amending the Constitution of the Slovak Republic. The article 20 para. 2 of the Constitution of the Slovak Republic reads as follows: The Act shall stipulate which other property, in addition to the property specified in Article 4 of this Constitution, is necessary to ensure the needs of society, **food security of the state**, the development of the national economy and the public interest may only be owned by the state, the municipality, designated legal entities or designated natural persons. The law may also stipulate that certain things may only be owned by citizens or legal

entities domiciled in the Slovak Republic. The Constitution of the Slovak Republic, therefore, allows the determination of limits on the right of ownership in the interest of maintaining the food security of the state. Food security is directly linked to food production, which is practically entirely dependent on agricultural land. The base of publicly owned agricultural land can therefore also serve to meet the objectives of maintaining food security, not only in the form of renting out these plots of land but also in the form of their usage for the implementation of joint facilities or measures that will prevent wind erosion and water erosion of the soil and help water retention in the country. The overall improvement of the condition of the country will thus also benefit other land managers.

The last part of the proposed preamble is based on the preamble to Act no. 229/1991 Coll. both in the following part—on rural economic development and in accordance with the requirements for land and environmental protection. This section is intended to reflect, as a matter of priority, the need to develop a plan for the implementation of joint facilities and measures, as already mentioned above. The plots of land of undetected owners pose complications in the construction of cycle paths, public buildings such as schools or hospitals, rental apartments, industrial parks, etc. Therefore, in the interests of rural economic development, municipalities and self-governing regions should also be able to acquire such plots of land within the scope of the proposed legal regulation—which guarantees the preservation of the plot of land under the public ownership regime. However, it should be exclusively the plots of land which are necessary to ensure their economic development. In the event that, in the future, municipalities and self-governing regions need further such plots of land, they will be able to apply to the State for their delimitation. It will be for the State to assess the significance and public interest in such provision of additional plots of land. In practice, there may be a situation where the municipality request the State for cooperation in the construction of apartment buildings, and the State, if it has plot/plots of land of sufficient quality, provides them to the municipality. Another example may be the situation where a self-governing region request the State for cooperation in the construction of a regionally important road or the Railways of the Slovak Republic requests the State for cooperation in the construction of the railway line. In all publicly significant cases, the State should provide the requesting entity which is able to maintain the plots of land of public ownership with the highest possible degree of synergy and help. The management of state land ownership should thus become a tool that will serve to meet the public benefit objectives. Unfortunately, the management of state land ownership currently pursues the primary economic objectives and protection of undetected owners. With the adoption of the Act on the Plots of Land of Undetected Owners, this approach should be radically reformed, however, that will require perfect preparation and precise planning in the management of publicly owned land.

The last requirement arising from the third point of the preamble relates specifically to the **area of environmental protection**, which is contained in a series of legislation and interferes with a series of rights and legally protected interests. Among other things, in the right to property, where, for example, in the form of a compulsory restriction occurs, compensation is paid to owners of forest lands on which

logging cannot take place due to their inclusion in the protection zone. The right to environmental protection is regulated in Article 44 of the Constitution of the Slovak Republic, into which the concept of agricultural and forest land was incorporated within the framework of the above-mentioned Act no. 137/2017 Coll., Amending the Constitution of the Slovak Republic no. 460/1992 Coll. as amended which reads as follows: Agricultural land and forest land as non-renewable natural resources enjoy special protection from the State and society. Among other things, within the meaning of Section 2 of Act no. 17/1991 Coll. on the Environment, as amended, the environment is everything that creates the natural conditions of the existence of organisms, including humans, and is a prerequisite for their further development. Its components are mainly air, water, rocks, soil, and organisms. Natural conditions for a person create being in a space in which his life, health, property, and his fundamental rights are protected. In the event of interference with human rights due to inaction by an unknown owner, it is necessary to create a tool that can eliminate or mitigate this interference to the necessary extent. From the point of view of components of the environment, it could be concluded that these all occur on the plots of land and are therefore closely linked to the effective management of the territory. The proposed Act on the Plots of Land of Undetected Owners should be a "green law" i.e. a law that will make a positive contribution to the protection and sustainability of the environment.

5 Conclusion

The initial proposal of the Ministry of Agriculture in form of preliminary information based on which it plans to prepare and propose for adoption the Act on the Plots of Land of undetected owners can be seen as a positive step that aims to solve the problem that has been burdening the system for more than thirty years. Historically, the legislature tried to solve the problem by adopting Act no. 180/1995 Coll., however, the form in which he tried it was declared unconstitutional by the Constitutional Court. In its finding, it pointed out shortcomings but also outlined a constitutionally formative way of dealing with the problem of the plots of land of undetected owners.

Through the method of analysis, we analyzed the relevant legislation, case law, and annual reports, as also the complaints raised in the legislative process regarding the preliminary information of the Act on the Plots of Land of Undetected Owners. Based on analytical knowledge, we have formulated, through the synthesis method, the core thesis on which, the future act should be based. Nonetheless, this contribution only deals with its basic particulars concerning basic terms and principles, which have an impact on the whole legal order of the Slovak Republic. It is quite astonishing that the legislator has not done so yet and therefore this problem persists in the Slovak Republic.

Using the method of synthesis and deduction, in the framework of the legislation, by pointing to specific provisions, we have deprived the possible nature of some substantive as well as procedural institutes in proposed proceedings. We conclude that

the procedure must undoubtedly indicate its intention, which is to restore ownership of the plots of land of the undetected owners and the subsequent expropriation of the remaining plots of land of the undetected owners to the State, which, however, will be able to use these plots of land exclusively in the public interest and will have to guarantee any compensation for the damage caused by expropriation.

As part of the method of deduction, we have identified and specified the public interest in the adoption of the Land Consolidation Act as well as the public interest in its application in a practice that is broad-spectrum and affects both the public and private legal quality of land ownership.

In the absolute conclusion of our contribution, however, we add that we are aware that the proposed legislation is intended to address a long-standing problem caused primarily by insufficient state ownership records by the state and yet has the ambition to interfere with the property rights of the individuals. We are therefore of the opinion that before the adoption of this act it will be necessary to initiate an interdisciplinary professional and scientific discussion, which will contribute to the transparency and fairness of the process itself leading to the end of one traumatic period of the Slovak Republic's history.

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References

1. Slovak Land Fund: Annual report 2020 [online] [cit. 1. June 2022]. https://pozfond.sk/wp-content/uploads/2021/08/SPF-v%C3%BDro%C4%8Dn%C3%A1-spr%C3%A1va-2020.pdf
2. Enviroportal: Land use [online] [cit. 1. June 2022]. https://www.enviroportal.sk/indicator/detail?id=161
3. For example: Act no. 229/1991 Coll. on Regulation of Property Relations to Land and Other Agricultural Property, as amended; Act of the Slovak National Council Act no. 330/1991 Coll. on Land Consolidation, Settlement of Land Ownership Rights, District Land Offices, the Land Fund and Land Associations, as amended; Act of the National Council of the Slovak Republic no. 180/1995 Coll. on Certain Measures to Organize Ownership, as amended
4. Finding of the Constitutional Court of the Slovak Republic no. PL. ÚS 11/05–39 of 22 August 2006, which was published in the Collection of Laws under no. 537/2006 Coll
5. National Council of the Slovak Republic (1994–1998), Parliamentary press no. 162—Government bill of the National Council of the Slovak Republic on Certain Measures for the Organization of Land Ownership [online] [cit. 1. June 2022]. https://www.nrsr.sk/dl/Browser/DsDocument?documentId=289470
6. National Council of the Slovak Republic (1994–1998), parliamentary press 776—Proposal of a group of members of the National Council of the Slovak Republic for the issuance of an Act amending Act no. 229/1991 Coll. on the regulation of ownership relations to plots of land and other agricultural property, as amended, Act of the Slovak National Council no. 330/1991 Coll. on Land Adjustments, Land Ownership Arrangements, Land Offices, Land Fund and Land Communities, as amended, and Act of the National Council of the Slovak Republic no. 180/1995 Coll. on certain measures to organize land ownership [cit. 1. June 2022]. https://www.nrsr.sk/dl/Browser/Document?documentId=129564

7. National Council of the Slovak Republic (1998–2002), parliamentary press 659—Government bill amending Act of the National Council of the Slovak Republic no. 180/1995 Coll. on certain measures for the organization of land ownership, as amended. https://www.nrsr.sk/dl/Browser/Document?documentId=137240
8. Act no. 219/2000 Coll. amending Act no. 503/2003 Coll. on the Return of Ownership of Plots of Land and on the Amendment of the Act of the National Council of the Slovak Republic no. 180/1995 Coll. on Certain Measures for the Organization of Landownership, as amended
9. Authors' note: If we take the scope of preliminary information as the basic criterion, the basic objectives of the legislation are described in this preliminary information is in 4752 characters, while in the case of preliminary information on the draft new building law—the Construction Act (preliminary information no. PI/2019/36) it was in 4267 characters and in the case of the draft law on landscape planning (preliminary information no. PI/2021/147) it is only in 353 characters.
10. Ministry of Agriculture and Rural Development of The Slovak Republic: Preliminary information no. PI/2022/109 Draft of Act on Plots Land of Undetected Owners [online] [cit. 1. June 2022]. https://www.slov-lex.sk/legislativne-procesy/SK/PI/2022/109
11. E.g. Section 4 para. 5, Section 10 para. 3, Section 10 para. 6 of the Act of the Slovak National Council no. 330/1991 Coll. on Land Consolidation, Land Ownership Arrangements, Land Offices, Land Fund and Land Associations
12. See: Pavlovič, M.: Štátna správa na úseku pozemkových úprav. In.: Szakács, A.. Durec Kahounová, M., Senková, S. (eds.): Mĺňiky práva v stredoeurópskom priestore 2020. Proceedings of the international online scientific conference of doctoral students and young researchers organized by Comenius University in Bratislava, Faculty of Law, Bratislava, pp. 180–189 (2020)
13. Srebalová, M., Peráček, T.: Challenges and perspectives of effective land consolidation: the case of Slovak Republic. In: Kryvinska, N., Greguš, M. (eds.) Developments in Information & Knowledge Management for Business Applications. Studies in Systems, Decision and Control, vol 420. Springer, Cham. https://doi.org/10.1007/978-3-030-95813-8_8
14. National Agricultural and Food CenterNational Agricultural and Food Center: About Us: Mission of NPPC [online] [cit. 1. June 2022]. http://nppc.sk/index.php/en/about-us/mission-of-nppc
15. See Section 8 para. 1 letter c) of Act No. 330/1991 Coll. on Land Consolidation, Settlement of Land Ownership Rights, District Land Offices, the Land Fund and Land Associations, as amended
16. See Section 8 para. 1 letter d) of Act No. 330/1991 Coll. on Land Consolidation, Settlement of Land Ownership Rights, District Land Offices, the Land Fund and Land Associations, as amended
17. Fečík, M.: § 134 [Vydržanie]. In: Bajánková, J., Dulak, A., Fečík, M., Sedlačko, F., Števček, M., Tomašovič, M. a kol.: Občiansky zákonník I. 2. edition. Prague: C. H. Beck, p. 1010 (2019)
18. Authors' note: Principle of the prohibition of the crumbling of agricultural and forestry land. For more details, see e.g.: Pavlovič, M.: Vlastníctvo pôdy a jeho špcifiká, In: JAKUBÁČ, R., MÁČAJ, Ľ., MARTVOŇ, A., MICHALOVIČ, M., PAVLOVIČ, M., VRABKO, M. Praktikum pozemkového práva. 1. vydanie. Bratislava: Wolters Kluwer SR s. r. o., 2021, pp. 28–37
19. See Judgment of the Constitutional Court of the Slovak Republic of 20 December 1995, no. zn. PL. ÚS 33/95
20. See Section 46 of the judgment James and Others v the United Kingdom, 21 February 1986, Series A no. 98
21. Article 20 para. 4 of the Constitution of the Slovak Republic: Expropriation or restrictions of right in property may be imposed only to the necessary extent and in the public interest, based on the law and for a valuable consideration
22. Klučka, J.: Medzinárodné právo a Ústava Slovenskej republiky. Košice: Medes, 1996, p. 10; Drgonec, J.: Article 3. In: Drgonec J.: Ústava Slovenskej republiky. Second edition. Bratislava: C. H. Beck, p. 282 (2019)

23. Máčaj, Ľ.: Úlohy pôdoznalectva a ochrany pôdy pri vykonávaní pozemkových úprav. In: Acta Facultatis Iuridicae Universitatis Comenianae Tomus XXXIX, issue 1/2022 (2022)
24. See Section 2 letter b) of Act no. 220/2004 Coll. on the Protection and Use of Agricultural Land and amending Act no. 245/2003 Coll. on Integrated Pollution Prevention and Control and on the Amendment of Certain Acts, as amended
25. See Section 3 para. 1 of Act no. 326/2005 Coll. on Forests, as amended
26. See Section 2 letter f) of Act no. 326/2005 Coll. on Forests, as amended

The Evolution of the Service Sector: Aspects in the e-Services Development and Management

Miloš Šajbidor, Marian Mikolasik, and Peter Veselý

Abstract From the beginning of the industrial revolution, services started becoming more important for the development of the modern economy. It is no coincidence that banks and railroads, two of the largest service sectors, had a very rapid growth at the same time as the Industrial Revolution. Without such services, it is arguable that the economic developments specific to the modern economy, like large-scale production, could never have been so quickly realized. Pilat projects that the twenty-first century will be dominated by services, as they already dominate most developed economies, given that significantly more than half of these countries' gross domestic product is in the service sector. One crucial phenomenon that dramatically changed the service sector appeared in the 1990s: The Internet and The World Wide Web. Beginning in the mid-1990s, when the Internet became available on a large scale, increasingly electronic services became widely available to mass consumers. The growth of the service sector can be seen as a manifestation of the changes brought by the Internet and the information revolution, which has brought great developments in computing, data storage, communication and interaction. The Internet brought many advantages to the service sector, like personalized service, high-quality customer service, and improved supply chain management, and therefore an increasing proportion of services started to be electronic services delivered over the internet.

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1 Definition of e-Service

Most definition of e-services [1–3] regards it as a service delivered electronically. Therefore, it is needed to define what service is first to adequately define e-services. Lovelock and Wirtz [4] define service as "an act or performance offered by one party to another an economic activity that creates value and provides benefits for customers…by bringing about the desired change in, or on behalf of, the recipient" [4]. This definition points out the process of creating value between two parties and the outcome, in the form of benefits, that the customer receives. Both the service production processes and the outcomes are relevant when we consider e-services [5, 6], as well. Coming back to electronic services, Javalgi, Martin, and Todd [7] define them as "those services that can be delivered electronically," and Boyer, Hallowell and Roth [8] see them as "interactive services that are delivered on the Internet using advanced telecommunications, information, and multimedia technologies" [8]. Regarding the process, an e-service is created and stored as an electronic code comprised of binary numbers typically implemented by networked software. Regarding the outcome, as the classical service, an e-service will deliver benefits to the consumer [9]. Therefore, the distinguishing features of e-service lie in the flexibility of algorithms and networked software. For example, let us take Google Calendar who create an algorithm to produce a calendar service. They program the algorithm in such a way to make different features, appearances, interactions and benefits that are different and more complex than a physical calendar could produce while visually maintaining the metaphor of a paper calendar. From the process point of view, e-services have the flexibility and may or may not be designed to imitate traditional service processes. In addition, they can be inventoried, repurposed, reassembled with different properties, recombined, customized, repackaged, re-branded, transferred or forwarded, delivered to various devices, and re-consumed [9]. From the outcome point of view, e-service is measured, like classic services, relative to customer expectations: Satisfaction depends on the comparison between the expectation and the experiential aspects of the service delivery process [9]. Another aspect of the definition of e-services is regarding the meaning of networked software or electronic networks. The main reference here is to the Internet, but is not limited to that. Other electronic environments such as mobile networks, ATMs, and self-service kiosks are also included by this definition [3]. “Service environments become increasingly complex when technology is implemented to execute specific processes to deliver a service. This ultimately adds to the complexity of a service environment, making it one of the most difficult environments to examine and manage service capabilities. Capabilities are complex, structured, and multi-dimensional. They may be described as fundamental determinants of resource utilization to support and sustain organizational performance.” [8] Some firms reject the assumptions underlying the cycles of failure or mediocrity. Instead, they take a longer term view of financial performance, seeking to prosper by investing in their people in order to create a cycle of success (Fig. 1). As with failure or mediocrity, success applies to both employees and customers. Attractive compensation packages are used to attract good quality

staff. Broadened job designs are accompanied by training and empowerment practices that allow frontline staff to control quality [4]. Lovelock defines three cycles of failure, mediocrity and sucsess. With more focused recruitment, intensive training, and better wages, employees are likely to be happier in their work and to provide higher quality, customer-pleasing service. Regular customers also appreciate the continuity in service relationships resulting from lower turnover and so are more likely to remain loyal. Profit margins tend to be higher, and the organization is free to focus its marketing efforts on reinforcing customer loyalty through customer retention strategies. These strategies usually are much more profitable than strategies for attracting new customers see Fig. 1.

Unlike goods, which can be detached from their immediate producers and sold on an anonymous market, services are given by their immediate producers and are not sold on an anonymous market. Consumers will be able to identify the direct producers (or will at least have the possibility to do so). It is commonly stated that services are simultaneously produced and consumed, necessitating face-to-face contact between producers and customers during the production/consumption phase. This may not always be the case, but in the case of repair work, consumption will begin immediately after the termination of production. The fundamental notion of services is unrelated to whether they are material or immaterial. For example, a plumber's repair work is

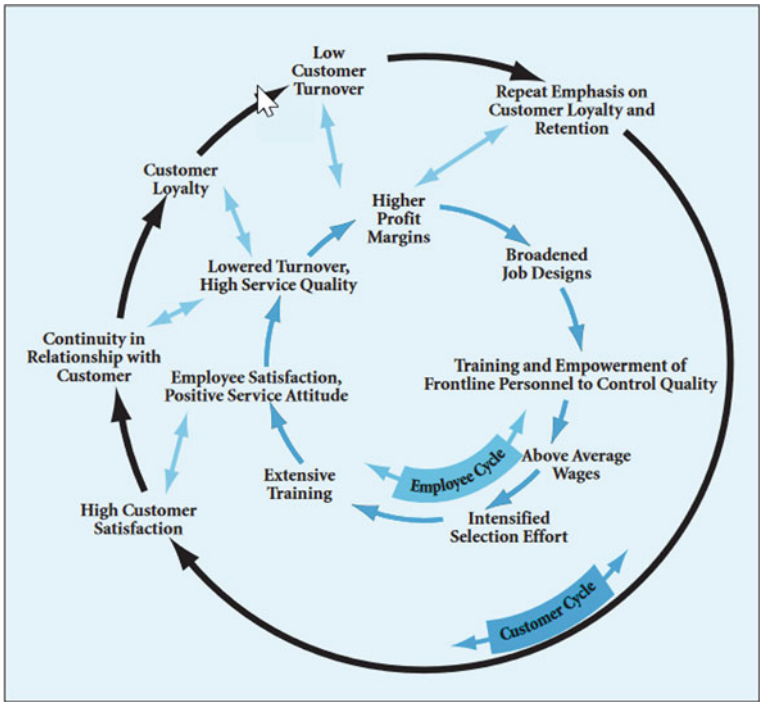

Fig. 1 The cycle of success [4]

material in nature but a service. Indeed, information and communication technologies (ICTs) influence the market transactions of all types of commodities and services (e-business). In contrast, the product itself is affected by data, information, and knowledge services (informational services). With the use of ICTs, it is possible to store data, information, and knowledge (to the extent that it can be codified) on digital media and utilize communication networks for transportation (e.g. Ahonen et al., 2008) [11]. This means that data, information, and knowledge services can be offered on anonymous markets with growing frequency. They transform into commodities in a sense. Historically, a paper was the major physical medium used to convert information services into tangible goods. Currently, electronic media are predominating. [12]

2 Main Proprieties of Services

Based on Hofacker, the most commonly-cited properties of classic services are [7]:

- Intangibility
- Heterogeneity
- The inseparability of production and consumption
- Perishability

In addition, according to Scupola [12], there are three main characteristics of e-services:

- The service is accessible via the Internet or other electronic networks.
- The service is consumed either directly or indirectly via the Internet or other electronic networks.
- There might be a fee that the consumer pays the provider for using the e-service (e.g. a surcharge for buying a movie ticket online), but that might not always be the case as is exemplified by some services offered by the government.

We will analyze each of them shortly, pointing out the distinguishing aspects of e-services over classical services.

2.1 Intangibility

One of the core attributes of services is that they are intangible. The intangibility of service is magnified when the service is digitized and offered as an e-service. The inherent differences that exist between traditional services and e-services produce a new set of challenges regarding the intangibility of the services. For example, e-services require that consumers interact with providers over greater distances which eliminate face to face communications, and must rely on computer mediated cues to reinforce a consumer's mental conceptualization of the service process [13]. You

can already begin to appreciate the problems related to service intangibility. The consumer is not sure exactly what they will be getting and how it will affect them. There is a lack of physical attributes inherent to many services and the potential outcomes thereof. So people have to imagine what might happen if they engage the service. That's a problem because it presents an unknown risk to the consumer. They don't know what they will get until they pay for it with their time and/or money (or both). This can, of course, drive many consumers away.

2.2 Heterogeneity

Heterogeneity represents variability in the quality of a particular service. Because e-services are mainly automated and less labor-intensive, there is less risk of human error and therefore tend to be far more homogenous than classic services. On the other hand, electronic services have a great impact on variability due to consumer participation, customization and personalization [9].

2.3 The Inseparability of Production and Consumption

E-services are highly flexible in terms of physical separation between consumer and producer [9]. A music group can record a live performance and then publish it online. We could say that the service production (performing the song) and the service consumption (listening to the song) are separated in space and time. The inseparability of production and consumption refers to the concepts of interaction and service encounter. The simultaneous production and consumption process involves the presence of customers, the customer's role as a co-producer, customer-employee and customer-customer interactions that make it unique from a product. Researchers often refer to the customers as 'partial employees' in a service setting. During co-production, customer involves himself in self-service (self check-in), using technology and machines offered by the service provider (airlines) [9].

2.4 Perishability

Classically it is believed that services are perishable. Vargo & Lusch [14] argue that, in some cases, services are not perishable and can be inventoried [14]. An e-service, being formed of data and algorithms, can be stored a server by the firm or on a local disk by the consumer. Unlike goods or classical services, electronic services in form of binary numbers delivered by software can be consumed over and over again without being used up. This aspect plays a big role in marketing such services. While classical services cannot be inventoried, e-services frequently have

Table 1 Differences between traditional and electronic services [9]

Services	e-Services
• Intangible	• Intangible
• It cannot be inventoried	• Can be inventoried
• Inseparable consumption	• Separable consumption
• It cannot be copyrighted	• Can be copyrighted
• Heterogeneous	• Homogenous
• Hard to price	• Hard to price
• Can't be copied	• Can be copied
• Can't be shared	• Can be shared
• Use equal consumption	• Use does not equal consumption
• Based on atoms	• Based on bits

the opposite problem in that they are too easily inventoried and the firm cannot prevent consumers from copying and exchanging. Based on Hofacker [9] we summarize the difference between, traditional services and e-services in Table 1.

Findings

Findings highlight the need for research into service innovations in the any sector at both macro-market and micro-firm levels, emanating from the rapid and radical nature of technological advancements [15].

Service and innovation capabilities

"Innovation is frequently dependent on a number of contributing factors. According to one theory, the following "conditions" contribute to sustained innovation:

(1) Shared understanding: cultural understanding of organizational behavior;
(2) Alignment: Aligning systems and processes to achieve desired performance metrics;
(3) Tools: Training, concepts, and techniques to innovate;
(4) Diversity: Optimizing external influences and insights to offer solutions within a specific domain;
(5) Interaction: Establishing platforms to exchange ideas and build networks; and
(6) Slack: Providing opportunities to access additional resource. These conditions contribute to the overall competencies and capabilities of the organization.

Due to their focus on internal processes, functions, and systems to meet customer needs, organizational capabilities may be regarded as the primary stability factor of a service operation.

When technology is introduced to execute particular service delivery processes, service environments grow increasingly complicated. This eventually contributes to the complexity of a service environment, making it one of the most challenging

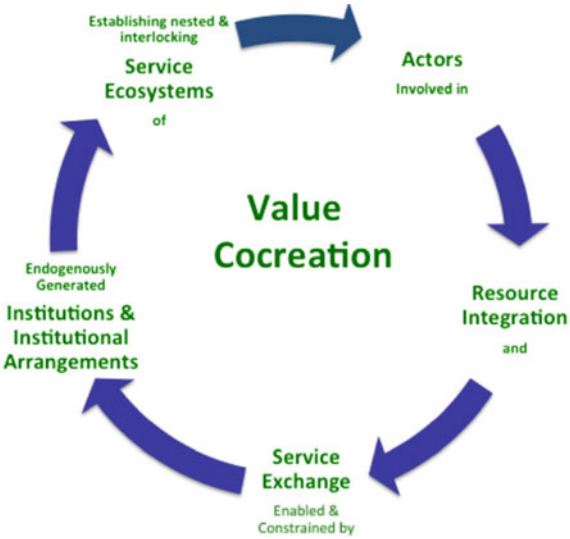

Fig. 2 The narrative and process of S-D logic [16]

contexts in which to assess and manage service capabilities. Capabilities are complicated, structured, and multi-dimensional. They are basic factors of resource utilization in support of and maintenance of organizational performance. Management of process maturity is well documented in business and information technology literature. In IT management, maturity models play a crucial and powerful role in organizational transformation. The availability of service and innovation capabilities has prompted us to reconsider our service environment conceptualization [10].

Service management theory has evolved through the lens of different eras, early contributors to its theory, early debates, the dominance and problems of intangibility, inseparability, perishability, and homogeneity (IHIP), and the current shift towards a service-dominant logic(SDL) (see Fig. 2).

Service-dominant logic continues its evolution, facilitated by an active community of scholars throughout the world. Along its evolutionary path, there has been increased recognition of the need for a crisper and more precise delineation of the foundational premises and specification of the axioms of S-D logic. It also has become apparent that a limitation of the current foundational premises/axioms is the absence of a clearly articulated specification of the mechanisms of (often massive-scale) coordination and cooperation involved in the co-creation of value through markets and, more broadly, in society. This is especially important because markets are even more about cooperation than about the competition that is more frequently discussed. To alleviate this limitation and facilitate a better understanding of cooperation (and coordination), an eleventh foundational premise (fifth axiom) is introduced, focusing on the role of institutions and institutional arrangements in systems of value co-creation: Service ecosystems. Literature on institutions across multiple social disciplines, including marketing, is briefly reviewed and offered as further support for this fifth axiom" [16].

The development of service-dominant logic The 2004 article in the Journal of Marketing [14] primarily did three related things:

(1) Identify an apparent trend in mainstream marketing thought, away from a principal focus on outputs (e.g., products) to processes (e.g., service provision, value creation);
(2) Identify commensurate commonalities in a number of diverse research streams and subdisciplines (e.g., relationship marketing, service marketing, business-to business marketing); and
(3) Identify and advance a convergence of these events on a shift from emphasizing production to emphasizing value (co)creation.

Given the article's positioning for the Journal of Marketing, and in keeping with mainstream marketing, its focus was relatively micro-level (i.e., firm-customer) and managerial, as evident in the language (e.g., co-production, competition, customer oriented)of several of the original FPs. Considering its original purpose and positioning, this was probably appropriate. However, the process of zooming out to a broader perspective on value co-creation began almost immediately, as evidenced in the distinction between co-production and the co-creation of value and the move from a dyadic orientation toward a network orientation (e.g., Lusch and Vargo 2006 [17]; Vargo 2008) [18]. More generally, the broadening can be seen in our suggestions that S-D logic might serve as a foundation for a theory of the market (Vargo 2007) [19], as well as a somewhat more limited, related general theory of marketing (Lusch and Vargo 2006) [17] and a more-encompassing theory of economics and society (Vargo and Lusch 2008) [18]. At the same time, often through the initiation of other interested scholars, we were connecting S-D logic to other research streams, such as consumer culture theory (CCT) (Arnould 2006) [20], service science (e.g., Spohrer et al. 2007) [21], and other disciplines (e.g., information technology and hospitality management) and subdisciplines (e.g., international marketing, logistics, service operations), even as the managerial implications were being further explored by us and others (e.g., Benttencourt, Lusch and Vargo 2014;Brodie et al.2006; Lusch et al. 2007) [22] [23] [19]. Much of this zooming-out movement, as well as the refinement of the lexicon of S-D logic, especially as related to the FPs, was initially more formally captured in an article (Vargo and Lusch 2008) [18] in this journal,Service-Dominant Logic: Continuing the Evolution, which reiterated previous changes in language, such as those associated with the co-creation of value and the distinction between service (a process) and services (units of output). It specified service as the basis, rather than the unit of exchange. It also formally changed FP9 from its original (Vargo and Lusch 2006) [17] firm-centric wording, dealing with the integration of micro-specializations, to a more generic all economic and social actors are resource integrators. FP10, Value is always uniquely and phenomenologically determined by the beneficiary, was also added. The modified FP9 implies a *network structure* for value creation and the new FP10 implies its contextual nature; both require a move from a single-minded concern with restricted, pre-designated roles of producers/consumers, firms/customers, etc. to more generic actors—that is, to an actor-to-actor (A2A) orientation" [16].

The importance of branding to the S-D logic is highlighted by Prahalad (2004) [25] in his invited commentary on the Vargo and Lusch article. He argues that Vargoand Lusch's sixth foundational premise 'the customer is always the co-producer'implies that there is a need to 'escape the firm and the product/service-centric viewof value creation and move on to an experience-centric co-creation view'(Prahalad, 2004: 23). Within this experience-centric co-creation perspective he argues that the brand becomes the experience. Prahalad (2004) [25] also suggests that brand meaning can evolve for the customer as a result of this co-creation of value (see Fig. 4).

The central role of brand experience and meaning in determining value wasformalized by Berry [24] in his model of service brand equity. In developing the model he points out that for goods-centric marketing the product is the primary brand, therefore the company's presented brand and external communications arethe major determinants of brand equity. However, when the service is the primary offer, Berry holds that the company becomes the primary brand or 'the service brand'. Thus, in this model, the customer's service experience plays the major rolein brand equity formation; creating 'brand meaning'. While his model also includes the influences of the company's presented brand and external communi-cations on awareness, he suggests that brand meaning rather than brand awarenessis the major determinant of brand equity (see Fig. 3). developed his model based on his research experiences withlabour-intensive services, but we see his model as appropriate to all organizationswhere the service offer is dominant and thus 'service' is super-ordinate to 'goods'and/or 'services'. However Berry's model provides only a starting point forunderstanding the role of 'the service brand' within the S-D logic [24].

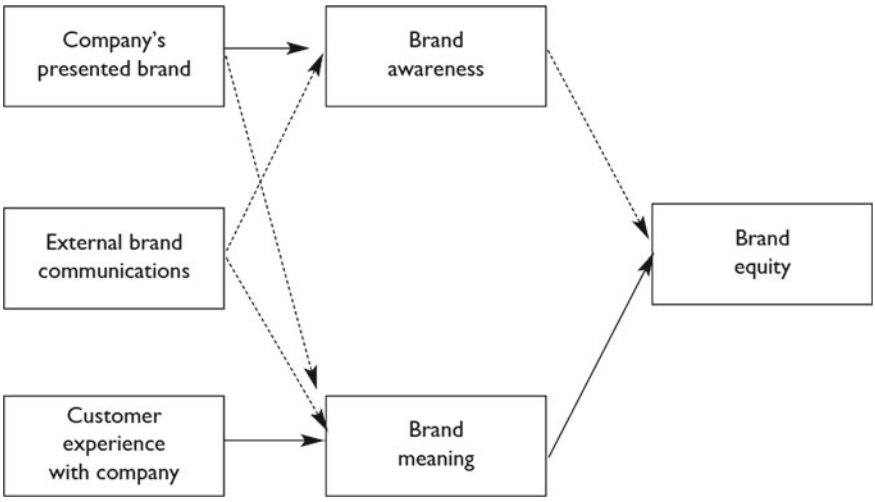

Fig. 3 Service branding model [24]

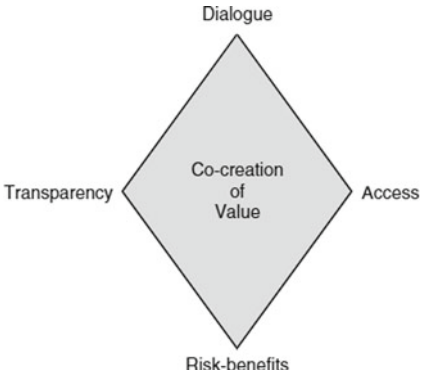

Fig. 4 Building block of interactions for cocreation fo value [25]

3 Distinct Characteristics of e-Services

Based on Riedl, we can point to certain characteristics of e-services as opposed to classical services. They identify five key areas of difference [3].

- The cost structure
- The degree of outsourcing
- The development of new services
- Transparent service feedback,
- The continuous improvement of services.

3.1 The Cost Structure

One of the key novelty brought by information technology is the new cost structure, both in comparison to physical products as well as to other non-electronic services. Typically, a cost structure of information technology requires high investment costs in order to develop the infrastructure and very low marginal cost. Once software is written and compiled, there is virtually zero cost involved with the software in providing the service it was written for. Added to that, copying and storing data has also very small costs. All these aspects reduce considerable variable costs [3].

3.2 The Degree of Outsourcing

Since e-services are highly flexible in terms of physical separation between production and consumption, outsourcing plays an important role. If there is no need to have locally the production of a service and the electronic services can easily be delivered from remote locations, there is no need to have them both in the same location [3]. Another aspect regarding the outsourcing possibility of e-service is the high

degree of technical standardization achieved through web standards combined with the availability of high-speed networks. This allows for easy integration with other providers that can offer the services needed [3]. One example of such a practices is the composite service offering on the internet like travel services, hotel service or transportation services. These networks of services take advantage of the outsourcing possibility as well as the specific cost structure of electronic services [3].

3.3 The Development of New Services

As e-services can be easily copied and replicated, the only way to attain a differentiation strategy is to innovate [3]. The electronic services sector has also low barriers of entry which contributes to a high competition and rapid advances of new technologies. The fast technological progress influences also the customers and rises the market standards. All these factors contribute to the rapid growth and development of new services in the electronic marketplace [3].

3.4 Transparent Service Feedback

E-services provide great opportunities to interact with customers and to solicit customer-relevant information to improve the service. Electronic technologies give the parties involved in the transaction the possibility to acquire a great amount of information about each other [3]. A service provider can gain access to detailed information about the customer behavior related to the transaction and can utilize that information to take advantage of various opportunities. In order to gain a competitive advantage, many firms realize this potential and use it to have a more informed decision-making process. Gathering and using data, especially in a competitive market, it is very important in order for firms to have in-depth knowledge about factors such as the customers, competitors, business partners, and economic environment [3].

3.5 The Continuous Improvement of Services

Talking into consideration the fast technological development and the use of data from the customers, the e-services sector experiences a continuous development and improvement of services. E-service technology enables organizations to personalize and customize their services depending on the unique "live" context and requirements, creating more value for the customer. The innovation process is short and allows a service to be improved very quickly [3]. As there are no geographical

barriers, a new innovation will be rapidly absorbed by the market and available to all users.

Open innovation environments

Open innovation is a relatively new concept that examines the creation of value through the external diffusion of innovation. The funneled approach of the open innovation model combines external technologies with internal capabilities in order to realign service delivery for a specific market opportunity. Open innovation presupposes that organizations should utilize external ideas and combine them with internal strategies to advance particular technologies and services. In many instances, organizations will form a business partnership to combine specific competencies and capabilities in order to achieve a particular objective while sharing the associated risk. This eliminates what were once considered to be boundary barriers and frees the flow of innovation transferability between organizations for knowledge distribution. The obvious cost savings required for an internal research team to develop new technologies is one of the primary motivators of open innovation. Today, businesses frequently opt for license agreements or joint ventures. Thus, open innovation has transformed the traditional notion of service capabilities as an internal resource into an external opportunity within the contemporary service environment. We will explain how the concepts of the open innovation model and the open service innovation environment share similar characteristics.

4 New Service Development—a Framework of Analysis

Based on the proprieties of services and the distinct characteristics of e-services, we will analyze the literature with regard to the applicability for the development of electronic services. Because the service sector is very competitive, the need for innovation drives firms to find new approaches to service delivery. As a result, new service development (NDS) has become an important factor that can lead to competitive advantage and has also raised researchers' interest in innovation management, marketing management and operations management [26]. NSD involves developing offerings such as financial services; health care; telecommunications services; information services; leisure and hospitality services; travel services; facilities management services; educational services; legal services; and consulting services [27]. Menor [28] takes into consideration the degree of innovation of a service as well as the service concept and defines a new service as a service not previously available that results from the addition of a new service or changes in the service concept [28]. Riedl [3] did a systematic literature review of the NSD with regards to their prescriptive support for designing and developing electronic services. They based the research on 63 journals and conference articles that were published between 1997–2008 and focused mainly on success factors and the development of process models [3]. Based on Riedl [3] we will analyze four key topics identified in NDS literature.

- Types of service innovation
- Antecedents of success
- Process models
- Generic and organizational aspects.

4.1 Types of Service Innovation

Johnson [29] suggests two main categories to structure service innovation: Radical innovation and Incremental innovation. Table 2 provides a more detailed description of the typology of new services) [3].

Other factors influencing service innovation have been identified by Hipp & Grupp [30] as knowledge intensity, network basis, scale intensity, and supplier dominance. From those, the network-based innovations seem to match most e-services due to their reliance on technology and communication techniques [3]. Regarding especially IT-based services, Barras [31] proposes a reverse product life cycle which suggests that innovation takes place in three phases: Improved efficiency, improved quality, and new services phase. He argues that, in the early life cycle phase of a service, "technology push" is the main driving force, and in the next phases, pressure by users will drive service providers to distinguish themselves by further innovation [3].

Table 2 Types of service innovation (adapted from Johnson et al. 2000) [3]

Radical innovations	
Major innovation	• New services for markets as yet undefined; innovations usually driven by information and computer-based technologies
Start-up business	• New services in a market that is already served by existing services
New service for the market presently served	• New service offerings to existing customers of an organization (although the services may be available from other companies)
Incremental innovation	
Service line extensions	• Augmentations of the existing service line such as adding new menu items, new routes, and new courses
Service improvements	• Changes in features of services that are currently offered
Style changes	• Modest forms of visible changes that have an impact on customer perceptions, emotions, and attitudes, with style changes that do not change the service fundamentally, only its appearance

Value creation within the modern service environment

The concept of value co-creation implies that customers play an important role in the creation of value within service systems [10]. Therefore, understanding the complexity of network structures, process patterns, and methods to improve network performance is essential to the success of service ecosystems, for both the service provider and the client, particularly in a smart service network [10]. As we shift from a chain-based to a service-network-based approach, the process of value creation in the modern service environment changes accordingly. We can investigate alternative ways of perceiving and comprehending service operations and the fundamental capabilities that support a service environment. In addition, Chesbrough [32] makes a compelling case for the necessity of shifting from a product-based perspective of service (such as Porter's value chain) to a service value web. This can be used to examine the cyclical nature of service maturity within an environment of open service innovation. Within the service value web, Chesbrough [32] explains that there is no simple linear transformation of inputs into outputs, but rather an iterative transformation that involves the customer throughout the entire process. While the service value web undergoes a number of key phases, its external interactions with customers also generate value. Consequently, the implementation of technological innovation frequently focuses on enhancing internal value. However, service maturity and value realization is a co-creation process involving the exchange of internal and external resources. This is crucial to open innovation for a variety of reasons. Understanding the nature of open innovation's service capabilities is becoming increasingly important for strategic planning within organizations" [10].

4.2 Antecedents of Success

Regarding the success of a newly developed service, two classes of success factors can be distinguished [33, 3].

- NSD outcome factors
- Performance measures of the NSD process itself

Adapted from Voss [33], Table 3 goes in detail regarding the success factors of a NSD [3].

Other reports in the literature regarding the success factors of NSD include continuous learning during the development process, managing key activities, and the right climate for innovation [3]. Posselt and Förstl [34] conducted a study on 48 papers and summarized the following success factors that influence the effectiveness and efficiency with which the service success factors are implemented. Regarding the role of employees in NSD, employee involvement and employee expertise play an important role. Furthermore, the process of NSD needs to have an appropriate level of formalization and the necessary management measures to promote development projects' success. Several authors have found a positive impact of customer

Table 3 Success factors of an NSD (adapted from Voss et al. 1992) [3, 31])

NSD outcomes	NSD process
Financial measures • Achieving higher overall profitability • Substantially lowering costs for the firm • Performing below expected costs • Achieving important cost efficiencies for the firm	**Criterion cost** • Average development cost per service product • The development cost of individual service product • Percentage of turnover spent on developing • new services, products and process
Competitive measures • Exceeding market share objectives • Exceeding sales/customer use level objectives • Achieving high relative market share • Having a strong positive impact on company image/reputation • Giving the company important competitive advantage	**Effectiveness** • How many new services are developed annually • Percentage new services that are successful
Quality measures • Resulting in service "outcome" superior to competitors • Resulting in service "experience" superior to competitors • Having unique benefits perceived as superior to competitors • Great reliability • More user friendly	**Speed** • Concept to service launch time • Concept to prototype time • Prototype to launch time • Time to adopt new concept from outside the firm

involvement in various stages of the development process, as understanding consumer requirements and desires have to be taken into account [35]. The electronic nature of e-services has specific influences on the NSD process, as noted above. Related to antecedents of success, the introduction of new service versions that are continuously released to customers is likely to have a major influence. Only if the increased service quality is perceived as such by service consumers, has the development process been successful. This leads to the question of how the continuously improved service can be successfully marketed to customers so that they are aware of the increased service quality [3].

4.3 Process Models

There are in the literature various process models defined for the development of new services. For example Johnson and Menor [29] proposed a basic model for new services development of four phases: Design, analysis, development, and launch [3]. Another model by Scheuing and Johnson [35] makes the distinction between the design of the service and the design of the delivery process and proposes seven steps in developing new services [27]:

- New product strategy
- Idea generation
- Screening and evaluation
- Business analysis
- Development
- Testing
- Commercialization.

Johnson [29] have developed a new NSD process as a continuous cycle enabling factors as teams, tools, and organizational culture. The cyclic nature suggest a non-linear processes typically employed in most NSD efforts. The NSD process cycle represents a progression of planning, analysis and execution activities [28]. The model revolves around the design and configuration of the service concept elements and those resources such as development teams and tools play an enabling function in the development process [28]. Figure 5 shows the NSD process cycle adapted from Johnson [29]:

Froehle & Roth [36] propose a framework for NSD in which both resource and process capabilities are required for successful service development. They integrate both process- and resource-oriented approaches. The resource-oriented approach focuses on developing the intellectual, organizational, and physical resources, and the process-oriented on planning, defining, and executing [3]. On a very generic level, Bessant and Davies (2007) suggest that organizations have to manage four phases in the innovation process: Search and scan their environment to pick up signals for potential innovation, strategically select those ideas that the organization will commit resources to, implement the innovation, and finally reflect on the previous phases to achieve organizational learning. What is not covered in these process models are the increased options for modularization, re-use, and outsourcing available for e-services.

In the literature on new product development, designing products to be easily manufactured (i.e., with fewer parts and minimal complexity) has been addressed (Swink, 1998) [37]. A similar issue has been addressed in NSD as "design for delivery" in an effort to reduce service delivery costs (Bullinger, Fahn, and Meiren, 2003) [38]. As many services (e.g., hospitality services) are labor-intensive, the motivation to optimize new services for efficient delivery is high. Due to the fact that electronic services have a reversed cost structure, as described previously, these

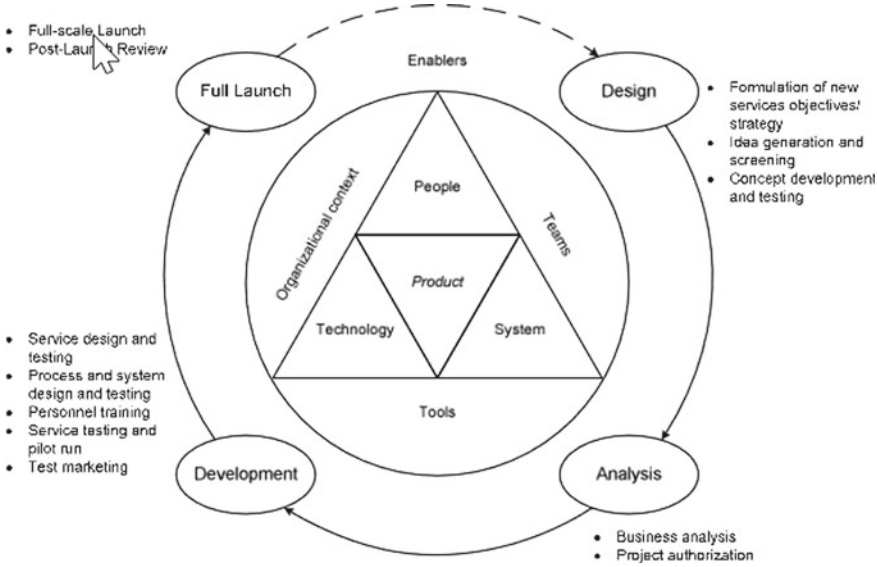

Fig. 5 Shows the NSD process cycle adapted from Johnson [29]

methods are unsuitable for e-service development. In contrast, it would be necessary to conduct additional research into ways to reduce the cost of developing new e-services. As the early phases of the development process, particularly the design and analysis phases, are the most costly they present opportunities for enhancement.

4.4 Generic and Organizational Aspects

One important aspect of NSD is the way new services are addressed in the organization. Different approaches can be pointed out, like project teams, business units, or complete organizations, but the nature of services (intangibility, heterogeneity, and inseparability) brings considerable complexities to the exchange processes of NSD. Therefore, the development of a network approach to NSD could provide firms with a source of competitive advantage, as interactions are critical for NSD and that the incorporation of different perspectives is beneficial to the innovation level [3].

As argued by Riedl et al. (2008) [3], perceived quality measures have to be taken into account to address satisfaction issues commonly addressed in "front-office" design. Moreover, Johnson et al. (2000) note that different NSD processes are necessary for different types of innovation. In particular, they identify incremental service innovations, radical service innovations, and technology-driven services as key differences that should be used to choose the appropriate NSD process; the authors propose this as an avenue for future research.

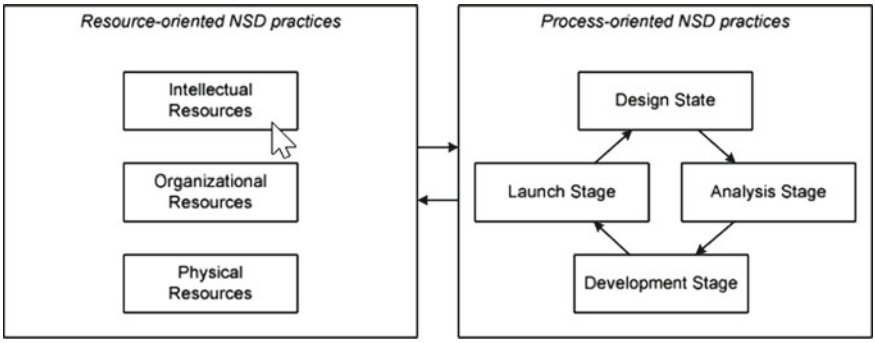

Fig. 6 The resource-process framework [3]

The resource-oriented practices focus on cultivating and developing the intellectual, organizational, and physical resources that support NSD capabilities. The process-oriented practices focus on planning, defining, and executing the actual stages of the service development (see Fig. 6). Their belief and motivation for this integrated view is that both resource and process capabilities are required for successful service development.

5 Gaps in e-Services Research

Reviewing the literature, one can notice that there are certain gaps in NSD research with regard to key attributes of electronic services. An important aspect that lacks proper coverage is the rapid nature and specific cost structure found in electronic services, as well as the transparent feedback generated by service usage, and the potential for continuous improvement and rapid deployment of service changes [3]. Based on Riedl) [3] the following gaps are proposed for a deeper exploration in future research. The specific cost structure found in electronic services create new types of services like bundling and composite services and mass customized services. It also has an influence on the process models, and efficient service development becomes even more critical for success. The fact that an e-service has high investment costs and low variable costs is important as costs will concentrate on the design process and not so much on the delivery. The specific rapid development of e-services creates the need for the development process to be customized toward speed or quality. The rapid development also impacts the market and the customer expectation. In order to have success, these expectations need to be met through rapid developments and the process models need to be tuned for speedy development of new services. At the organizational level, the firm needs to adapt and deliver on the shorter service life cycles and the increased speed of development [3]. Another characteristic of e-services that needs more research is transparent service feedback. These characteristics benefit incremental service innovation as feedback integration into the process

model becomes easier as feedback is readily available. Customer feedback needs to be incorporated in the organization as the customer integration is an important factor in success. Regarding the continuous improvement and deployment of e-services, as is relatively easy to make minor changes, it is needed to make them visible to the customer in order to ensure the success of the improved services. The process models need to develop a cycle-based process in order to support continuous improvement and deployment, and the organization need to be able to learn and develop its skills to manage such processes [3].

6 Conclusion

In conclusion, despite its increasing importance, the research on e-services and new service development is still limited. This paper approached the key aspects that distinguish non-electronic from electronic services, highlighted the areas of interest regarding new service development, and pointed out to gaps in the literature that could be addressed by future research. The shift from classical IHHP to service-dominant logic SDL was discussed with a focus on value co-creation. While more research is needed to better understand e-services and the development of new services, one aspect remains important: Survival for many electronic services rests on the ability of the firm to respond to the rapid technological development of the market.

References

1. Rahman, Z.: A model for the sales and distribution of E-Services. Serv. Mark Q. **26**, 71–87 (2004). https://doi.org/10.1300/J396v26n01_05
2. Pilat, D.: OECD Observer: No longer services as usual. https://ciaotest.cc.columbia.edu/olj/oo/oo_win00u.html. Accessed 30 Jun 2022 (2000)
3. Riedl, C., Leimeister, J.M., Krcmar, H.: Why e-Service development is different: a literature review (2010)
4. Lovelock, C.H., Wirtz, J.: Services marketing: people, technology, strategy, 9th edn. World Sci., New Jersey (2022)
5. Poniszewska-Maranda, D., Matusiak, R., Kryvinska, N., Yasar, A.-U.-H.: "A real-time service system in the cloud," J. Ambient Intell. Human Comput. **11**(3), pp. 961–977, https://doi.org/10.1007/s12652-019-01203-7 (Mar. 2020)
6. Fedushko, S., Ortynska, N., Syerov, Yu., Kravets, R.: E-law and E-justice: analysis of the Switzerland experience. In: CEUR Workshop Proceedings. Vol-2654: Proceedings of the International Workshop on Cyber Hygiene (CybHyg-2019). Kyiv, Ukraine, November 30, pp. 215–226. http://ceur-ws.org/Vol-2654/paper17.pdf (2019)
7. Javalgi, R.G., Martin, C.L., Todd, P.R.: The export of e-services in the age of technology transformation: challenges and implications for international service providers. J. Serv. Mark **18**, 560–573 (2004). https://doi.org/10.1108/08876040410561884
8. Boyer, K.K., Hallowell, R., Roth, A.V.: E-services: operating strategy—a case study and a method for analyzing operational benefits. J. Oper. Manag. **20**, 175–188 (2002). https://doi.org/10.1016/S0272-6963(01)00093-6

9. Hofacker, C.F., Goldsmith, R.E., Bridges, E., Swilley, E.: E-Services: A synthesis and research agenda. In: Evanschitzky, H., Iyer, G.R. (eds.) E-Services: opportunities and threats, pp. 13–44. DUV, Wiesbaden (2007)
10. Carroll, N., Helfert, M.: Service capabilities within open innovation: Revisiting the applicability of capability maturity models. J. Enterp. Inf. Manag. 28:275–303. https://doi.org/10/gdk2td (2015)
11. Ahonen, P., Alahuhta, P., Daskala, B., et al.: Recommendations for stakeholders. In: Ahonen, P., Alahuhta, P., Daskala, B., et al. (eds.) Safeguards in a world of ambient intelligence, pp. 253–265. Springer, Netherlands, Dordrecht (2008)
12. Scupola, A., Henten, A., Nicolajsen, H.: E-Services: Characteristics, scope and conceptual strengths. IJESMA **1**, 1–16 (2009)
13. Featherman, M.S., Wells, J.D.: The intangibility of e-services: effects on perceived risk and acceptance. ACM SIGMIS database DATABASE Adv. Inf. Syst. **41**, 110–131 (2010). https://doi.org/10.1145/1795377.1795384
14. Vargo, S.L., Lusch, R.F.: The four service marketing myths: Remnants of a Goods-based, manufacturing model. J Serv Res **6**, 324–335 (2004). https://doi.org/10.1177/1094670503262946
15. Buhalis, D., Harwood, T., Bogicevic, V., et al.: Technological disruptions in services: lessons from tourism and hospitality. J. Serv. Manag. **30**, 484–506 (2019). https://doi.org/10.1108/JOSM-12-2018-0398
16. Vargo, S.L., Lusch, R.F.: Institutions and axioms: an extension and update of service-dominant logic. J. Acad. Mark Sci. **44**, 5–23 (2016). https://doi.org/10.1007/s11747-015-0456-3
17. Lusch, R.F., Vargo, S.L.: Service-dominant logic: Reactions, reflections and refinements. Mark Theory **6**, 281–288 (2006). https://doi.org/10.1177/1470593106066781
18. Vargo, S.L., Lusch, R.F.: Service-dominant logic: continuing the evolution. J. Acad. Mark Sci. **36**, 1–10 (2008). https://doi.org/10.1007/s11747-007-0069-6
19. Vargo, S.L.: On a theory of markets and marketing: From positively normative to normatively positive. Australas Mark J. **15**, 53–60 (2007). https://doi.org/10.1016/S1441-3582(07)70029-0
20. Arnould, E.J.: Service-Dominant logic and consumer culture theory: Natural allies in an emerging paradigm. In: W. Belk R, F. Sherry J (eds.) Consumer culture theory. Emerald Group Publishing Limited, pp. 57–76 (2007)
21. Spohrer, J., Maglio, P.P., Bailey, J., Gruhl, D.: Steps toward a science of service systems. Computer **40**, 71–77 (2007). https://doi.org/10.1109/MC.2007.33
22. Bettencourt, L.A., Lusch, R.F., Vargo, S.L.: A service lens on value creation: marketing's role in achieving strategic advantage. Calif Manage Rev. **57**, 44–66 (2014). https://doi.org/10.1525/cmr.2014.57.1.44
23. Brodie, R.J., Glynn, M.S., Little, V.: The service brand and the service-dominant logic: missing fundamental premise or the need for stronger theory? Mark Theory **6**, 363–379 (2006). https://doi.org/10.1177/1470593106066797
24. Berry, L.L.: Cultivating service brand equity. J. Acad Mark Sci. **28**, 128–137 (2000). https://doi.org/10.1177/0092070300281012
25. Prahalad, C.K., Ramaswamy, V.: Co-creation experiences: The next practice in value creation. J Interact Mark **18**, 5–14 (2004). https://doi.org/10.1002/dir.20015
26. Posselt, T., Förstl, K.: Success factors in new service development : A literature review. Fraunhofer Verlag (2012)
27. Johne, A., Storey, C.: New service development: a review of the literature and annotated bibliography. Eur. J. Mark **32**, 184–251 (1998). https://doi.org/10.1108/03090569810204526
28. Menor, L., Tatikonda, M., Sampson, S.: New service development: Areas for exploitation and exploration. J. Oper. Manag—J OPER MANAG **20**, 135–157 (2002). https://doi.org/10.1016/S0272-6963(01)00091-2
29. Johnson, S.P., Menor, L.J., Roth, A.V., Chase, R.B.: A critical evaluation of the new service development process: Integrating service innovation and service design. In: New service development: creating memorable experiences, pp. 1–32. SAGE Publications Inc., Thousand Oaks (2000)

30. Hipp, C., Grupp, H.: Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies. Res. Policy **34**, 517–535 (2005)
31. Barras, R.: Interactive innovation in financial and business services: The vanguard of the service revolution. Res. Policy **19**, 215–237 (1990). https://doi.org/10.1016/0048-7333(90)90037-7
32. Chesbrough, H.: Business model innovation: Opportunities and barriers. Long Range Plann. **43**, 354–363 (2010). https://doi.org/10.1016/j.lrp.2009.07.010
33. Voss, C.A.: Applying service concepts in manufacturing. Int. J. Oper. Prod. Manag. **12**, 308–313 (1992)
34. Posselt, T., Förstl, K.: Success factors in new service development : In: A Literature Review. RESER Conference (2011)
35. Scheuing, E.E., Johnson, E.M.: New product development and management in financial institutions. Int. J. Bank Mark **7**, 17–21 (1989). https://doi.org/10.1108/EUM0000000001454
36. Froehle, C.M., Roth, A.V.: A Resource-process framework of new service development. Prod. Oper. Manag. **16**, 169–188 (2009). https://doi.org/10.1111/j.1937-5956.2007.tb00174.x
37. Schmenner, R.W., Swink, M.L.: On theory in operations management. J. Oper. Manag. **17**, 97–113 (1998). https://doi.org/10.1016/S0272-6963(98)00028-X
38. Bullinger, H.-J., Fähnrich, K.-P., Meiren, T.: Service engineering—methodical development of new service products. Int. J. Prod. Econ. **85**, 275–287 (2003). https://doi.org/10.1016/S0925-5273(03)00116-6

Digital Transformation of SMEs During the COVID-19 Pandemic

Gutola Bokayo Roba and Mrva Milos

Abstract In recent years, the development of the digital economy has been in full swing, and major companies have begun the digital transformation. For small and medium-sized enterprises (SMEs) that play an important role in national economies, digital transformation is even more important. It is a hot spot and a difficult point for the government and the industry. The Covid-19 pandemic had a major impact on the survival and development of SMEs. Digital transformation is of great significance for SMEs to enable them to better respond to the pandemic, to ensure continuity of work and production and of course enhance their future competitiveness. Under the impact of the Covid-19 pandemic, the digital transformation of SMEs has ushered in new opportunities, as well as challenges and difficulties. This paper analyzes and studies the characteristics of Germany's SMEs, its characteristics, challenges, and opportunities brought about by the COVID-19 pandemic and the inevitable digital transformation during this period. In Germany, SMEs occupy a special position within the economy and COVID-19 increasingly affected the business models and livelihood of these companies. Even though digital transformation is not a new concept, COVID-19 showed that its increasingly difficult to remain competitive without it, hence speeding up the process for some while others had to adapt by adopting digitalization to survive.

Keywords Digital transformation · COVID-19 pandemic · Small Medium Enterprises (SMEs)

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1 Introduction

1.1 Relevance

When the outbreak of COVID-19 happened at the beginning of 2020, a lot of organization found themselves caught off guard. The worldwide pandemic established a new reality that nobody expected and rapid adaptations became necessary for the economic survival. One of these adaptations is digital transformation: Before the beginning of the crisis, many organizations were aware of the importance and digitalization in the twenty-first century however it may not have been a priority. This changed after the outbreak because the new situation left them with no choice [1]. Thus, COVID-19 did not only a big challenge for companies, but also be seen as a chance for digital transformations [2].

These aspects are especially relevant for small and medium-sized enterprises (SMEs). As a significant part of the society and the global economic, they play an important role in times of global crisis. Not only because they are differently impacted and handle the consequences from the pandemic differently than larger organizations, but also because they have a unique relationship with digital transformation processes. Accordingly, the impact of COVID-19 on SMEs is particularly relevant for the development of the worldwide economic situation, the further course of the pandemic and for the circumstances afterwards [3, 4]. Therefore, several studies already analyzed the concrete influence of the pandemic on SMEs: [4] investigated the impact of COVID-19 on European SMEs and evaluate the political responses [2]. Reviewed the pandemical influence on the digital transformation in SMEs about their sustainability. Furthermore, the challenges and opportunities for companies in a post COVID-19 world were studied by [5]. Based on these different studies, the research question for this paper was developed which is as follows.

To what extent have the circumstances of the COVID-19 pandemic influenced the digital transformation in small and medium-sized enterprises (SMEs), and can this influence be seen as an opportunity or a challenge?

The following paper will answer the research question in several steps—discussing several relevant factors and topics. There will also be a closer at Small Medium Enterprises (SMEs), SMEs in Germany, characteristics of these SMEs. Then a general look at the impact and current situation regarding COVID-19 will be described, consequently taking a closer look at the economic consequences of the pandemic. Then digital transformation will be introduced, defined and implementation strategies will be discussed. Then, the status quo before the pandemic will be addressed. The last part of the chapter will include the impact of COVID-19 on the digital transformation globally. Thereupon, SMEs will be defined, their relevance and characteristics discussed in relation to digital transformation and COVID-19 era. Challenges and opportunities when it comes to SMEs and digital transformation during the crisis will be discussed next.

Last but not the least, the results and findings will be summed up, concluded, an evaluation and recommendations will be given—regarding the research questions.

2 Theoretical and Conceptual Background

2.1 Small and Medium Sized Enterprises

Small and medium-sized enterprises are the core of the economy, with a large number of so-called hidden champions, market leaders in niche areas, they significantly promote the general welfare of society through jobs, taxes, and increased attractiveness of a country as a business location. Already in the past, growing competitive pressure has been felt in the context of increasing globalization. International interconnectedness, sophisticated supply routes and lower wages with a high degree of innovation threatened to undermine profit margins of long-established medium-sized companies. China, with double-digit growth rates per year, is to be considered relevant here [6].

China came to the attention at the beginning of 2020 with the first emergence of the SARS-COV-2 virus (Severe Acute Respiratory Syndrome Coronavirus 2). Its rapid spread and comparatively higher lethality rate, combined with some increasingly severe long-term effects, led to a so-called "Global society shock" and prompted the World Health Organization to classify the virus as a global pandemic. Governments around the world began to impose strict lockdown measures [7].

A core measure to stop the spread of the virus was the reduction of human contact, so-called social distancing as described by the Red Cross. This was accompanied by the closure of retail stores and a widespread shutdown of non-digital businesses. Threatening effects were already apparent at the beginning when the shutdown of factories in China triggered worldwide supply shortages in various sectors. The disruptions to everyday business and personal life did not remain without effect: A report by [8] suggests that within the Euro- zone GDP has fallen by 3.8% in the first quarter. This represents the sharpest drop since records were first compiled in 1995, ranging from –4.7% to –5.8% in Italy, Spain, and France [7].

Even before COVID-19 hit, 92% of companies thought their business models would need to change given digitization [9]. Companies that already have a high level of digital maturity have the understanding that change is always present, and an appropriately rapid response is needed [9]. The majority, however, were completely unprepared for the crisis. Even companies that at first glance appeared to be well positioned with their business model were in part overwhelmed by the newly emerged demand for their manufactured goods due to their low level of digitalization and agility [9].

However, the pandemic should not be seen as a trigger for these problems, but rather as a magnifying glass that points to existing deficiencies. For this reason, this paper will deal with the aspects of digitization of small and medium-sized enterprises.

2.2 General Impact of COVID-19 and the Current Situation

At the end of 2019, the corona virus disease (COVID-19) broke out, spread rapidly, and became a global pandemic in a very short period. First discovered in Wuhan, China the outbreak caused global health emergencies, as well as a global economic slowdown [10] and nowadays, the pandemic is one of the greatest challenges to humankind since World War Two [11].

First and foremost, the COVID-19 pandemic can be defined as a global health crisis [12]. Currently, the number of worldwide COVID-19 cases remains at the highest level since the beginning of the pandemic. Weekly numbers of over 5.7 million new cases are reported and the number of deaths is also rising continuously. More than a year has passed since the beginning of the pandemic and there is still a variety of unanswered questions [13]. There are the direct noticeable impact of the virus and indirect but serious impacts too: The pandemic affected the living situation of the global population in many aspects. More than 1.5 billion students have been affected by the closure of educational institutions, many people are living in poverty and in general, a high number of young and old people is suffering from the consequences. These trickle-down effects are not limited only to the social aspects.

The pandemic also brought about strong economic disruptions in different ways [11]. The global lockdown caused volatility, uncertainty, complexity, and ambiguity across the social, economic, political, and technological environment also called "VUCA" [9]

VUCA was introduced at the end of the cold war to describe the unstable geopolitical conditions. Nowadays the acronym is often used to characterize chaotic, turbulent, and rapidly changing business environments. Accordingly, the approach can be used well for the ongoing COVID-19 pandemic and the events and actions taken on global and national levels to contain the spreading of the virus. Volatility sums up significant and rapid changes that occur over a short period of time, while complexity describes multiple key decision factors and their independence. This state can occur with certainty or uncertainty—however, when a situation is both, uncertain and complex, it becomes very difficult to address. Ambiguity refers to a lack of clarity regarding the actions that need to be taken [14] (Fig. 1).

The framework classifies volatility as an unexpected and unstable event that occurs over an unknown period and even if knowledge about the situation is available, predictions of the results are unsure and hard to make. In case of the COVID-19 pandemic

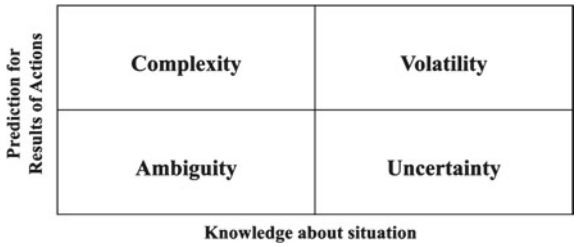

Fig. 1 VUCA framework [16]

this applies for the rapid and unexpected increase of case numbers since the outbreak. Accompanied with little understanding of the disease, the first step was to contain the spreading by following standard prevention measures. Predicting something about the future without having information makes a situation uncertain. To overcome this state, investment in information at the ground level is necessary. On this way, more accurate predictions are possible. The outbreak of COVID-19 has created a globally uncertain situation: Almost every prediction model has failed and many times not enough information have been shared to enable healthcare professionals to take appropriate measures. Complexity describes an event or a situation with many connected and interlinked components and only a limited amount of available information—as well very clearly visible in the pandemic. A number of different levels is affected, among them social and cultural practices, as well as economic and political dimensions. To understand this complexity, governments formed task forces and large sums of money have been invested in research of the virus. Relationships that are unclear and do not have precedents available are called ambiguous. Ambiguity in this case describes the uncertainty surrounding the COVID-19 measures, different and changing rules on restrictions and lockdowns as well as discussions on the necessity of complete lockdowns and the relevance of different restriction measures [14]. The VUCA framework shows that different consequences affect various levels and dimensions. One of these dimensions is especially important and cannot be ignored: The fact that the outbreak not only caused a global health crisis, but also a worldwide economic crisis, which is going to have long-term consequences for the entire population [12]. Thus, the pandemic not only has a negative impact on the general quality of life or the global economy but has severe effects on both aspects [11].

2.3 Economic Consequences

Due to the health risk of COVID-19, strict measures to contain the virus were taken. These measures among other things included the isolation of workers and consumers, closure of factories, stores and shops and bans from sports and entertainment activities. Worldwide, the government and politicians took various actions to curb the virus, based on assessments and advice from experts and different virologists.

The problem was that these suggestions by experts were only considering the health aspect of the situation, without considering the consequences on the economy. Thus, these recommendations pose an immediate threat to the economy [12].

The most efficient solutions for the health crisis and for the economic crisis are contradictory and fundamentally, the economic decline itself has an adverse effect on the general health: Due to the reduction of economic activities, the circulation of money decreases and consequently, tax revenues are significantly lower. The result: A reduced availability of finances that could be used for public-health countermeasures—which are crucial to get the COVID-19 pandemic under control [12].

There are also a number of factors where the consequences of the outbreak differ depending on various settings. One of these settings is the access to free healthcare,

as well as income protection: If free healthcare is available for a workforce and furthermore, if they have a secured income, the situation outcome is different than in an environment where people must choose whether to go work when they are ill because the alternative would be starvation [12].

Some sectors have almost completely collapsed: Not only car sales decreased in a large part of countries about 92%, but also sales in restaurants dropped approximately 95% [12]. In Europe, 60 million people are or were at risk of losing their job or having their monthly salary cut due to the pandemic [15]. Furthermore, the scale of the economic damages is hard to predict, since nobody knows how long the restrictions last and accordingly, how long the economy will be cut back. Normally, the economy is a complex adaptive system that has a degree of resilience when it comes to situations where it is necessary to bounce back from a shock. But after a certain period, a point is reached at which the compensatory mechanisms break down. Due to uncertainty about the number of waves or a series of waves of the pandemic, the outbreak of COVID-19 makes it almost impossible to calculate if bouncing back from the consequences is possible [12].

With all these challenges, a tension between traditional business processes and more digital mature organizations have become clear. Many organizations faced necessary digital changes that have interfered with their previous business processes. During the pandemic, a transformation towards more digitalized company procedures became significantly relevant and this is also seen in the numbers [9] (Fig. 2).

Digital transformation plays an important role for the economic survival and maintenance in the COVID-19 crisis. Not only for organizations, but also for educational institutions and fundamental communication and exchange. In a world, where face-to-face encounters became a rarity, technology is one of the few solutions to create a new form of normalcy [11]. And that brings us to the big question, what is digital transformation?

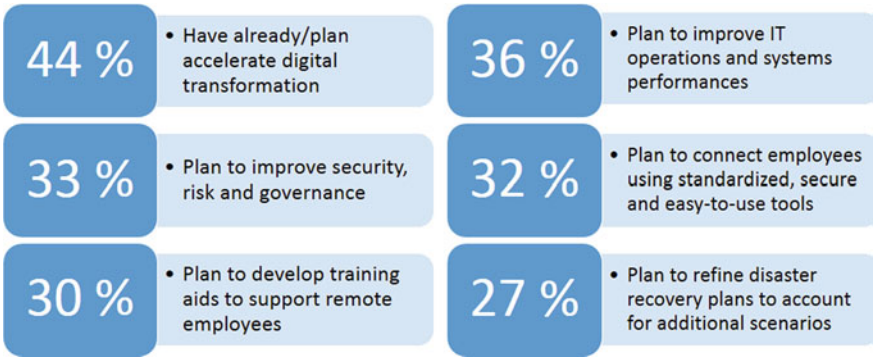

Fig. 2 Business plans resulting from COVID-19 [16]

3 Digital Transformation

3.1 Definition and Implementation

Through digital technology, companies can transform business models more quickly without following traditional and linear ways. This initiative of using new capabilities can be defined as digital transformation. Among them are technological innovations like 5G, artificial intelligence and 3D printing [19]. Other possibilities are the installation of solar panels, the switch to electronical cars and the use of recycled materials for manufacturing processes [20]. The goal: Improving an organization's performance and reach. The process: Comprehensive and often radical [2].

Thus, digital transformation is "a change in all job and income creation strategies, application of a flexible management model standing against competition, quickly meeting changing demands, a process of reinventing a business to digitize operations and formulate extended supply chain relationships; functional use of internet in design, manufacturing, marketing, selling, presenting and is data-based management model" [21]. It should not be seen as a technical leap but instead as "adaptation of its institutional and operational ecosystems of any entity in terms of new business and thinking methods in an attempt to keep a pace with digitization by benefitting from digital factors". Digital transformation is more than digitalization and includes the adaptation of the whole business model of an organization to be more flexible [20].

Through the rearrangement of technology, new values that are often necessary to meet the demand of customers and employees are created. The bottom line: The focus on efficiency and effectiveness—both are always connected to the customer. Thus, while implementing digital transformation the improvement of the consumer experience should be considered at any time. This can mean various things in different sectors. Whereas in the manufacturing industry, the automation of processes to deliver products with better quality in a shorter amount of time would be such an option, in the service industry [23, 24] it would be more likely to improve and digitalize the communication and contact points to the customers [22].

In general, there are different steps that are necessary or recommended for the implementation process of digital transformation:

1. The suggestion must come from the management: It is important that a process including significant and important changes is led by someone who has the power to initiate such adjustments. The current situation of the organization has to be analyzed, as well as the potential risks and challenges of the digital transformation and the influence on the future business.
2. In an organization where digital transformation is planned or implemented a "learning culture" needs also to be adapted. Since the world is changing in a rapid and unpredictable pace, not only skilled workers are needed, but also continuing education for the existing workforce is necessary to compete with the existing market.

3. A roadmap for the digital transformation and the planned goals has to be established and needed resources regarding time, finances, quality, and space have to be calculated.
4. Awareness has to be created: The need for change has to become clear, as well as the relevant steps and the desired goals. An understanding environment is essential to establish change, as well as a transparent communication.
5. Consultation with experts is in many cases necessary and always a helpful addition when implementing changes regarding the digital transformation process. Thus, collaboration with different helpers, like innovations labs and research institutes can be of significant relevance.
6. Support by the government. Especially small and medium-sized enterprises often do not have the capacity or resources for major changes and adaptations. Not only to generate an easier access to better and more assistance concerning the digital transformation process, but also as support for the analysis of requirements and needs.

[20, 25], define a maturity model including eight dimensions for the digital transformation process. Among them are the strategy, leadership, products, operations, culture, people, governance, and technology. Regarding these dimensions, different levels of digital transformation can be reached: If an organization has no strategy for digital transformation, as well as no needed competencies, the first level, calling "unaware", applies—due to the fact that no awareness relation to digital transformation exists. Companies with a few digital products, but also without a strategy are classified by the "conceptual" level. Level three, the "defined" level, takes organizations into account that are able to use previous experiences gained from pilot implementations and transform them into partial strategies. A culture of digital thinking starts to develop, and the company is on its way to a digital strategy. After a clear digital strategy is developed, the "integrated" maturity level is reached. The last stage, the "transformed" level, is only reached if the digital transformation is implemented for all products and business processes. At this point, the whole business model of a company will be adapted. In general, the maturity model can be a helpful tool for organizations to classify themselves and their current stage of digital transformation [22].

After defining a company's digital maturity position, the begin or further implementation of digital transformation can be realized in different ways. [26] discusses two possibilities for approaching a change from within a firm, as opposed to the standard strategic top-down approach. For one, there is the radical approach, requiring larger steps, if not jumps from an organization toward the realization of digitalization. The second concept is continuous improvement—focusing on consistently and gradually transform a company [26]. Both approaches have different strengths and weaknesses, which raises the question if either one of them is sufficient on their own: The radical approach comes with an extremely high risk, especially since the whole process of digitalization often is an unknown field. Continuous improvement instead limits the progressive change due to the lack of innovation and makes it questionable if an organization will ever be a market leader in such a dynamic and innovative environment [27].

In general, there are several different definitions, approaches, and implementation strategies regarding digital transformation, and it is often necessary to consider the external factors and the circumstances of the environment, to figure out which classification and which concept is most suitable.

3.2 Status Quo Before the Pandemic

Basically considered, every organization has the same goal: Meeting the demands of their customers to turn a profit. To do so, it is significant to consider the effect digitalization and its transformation has. The behavior of the customers is changing constantly, not only showing that they are less and less forgiving of mistakes, but also that their loyalty regarding one single organization is decreasing continuously. This is due to different reasons: Nowadays, customers are better informed and can use this unbiased information to form an opinion. Through the communication with other consumers and the mutual exchange, expectations are formed—especially regarding digital service provisions that span over all available channels and industries. Thus, the demands from customers are permanently increasing, which can be a challenge for many organizations [24].

But this is not the only factor that impacted the necessity for change and for digital growth in companies. Another significant aspect is the competition through the globalization that is getting tougher and tougher. A lot of new ventures are highly digitally focused and innovative, and many firms feel the pressure adjust their business model and become more digital. The market is constantly changing and if you do not want to be left behind, you have to act quickly [24].

However, since digital transformation is more than the introduction of new systems, such as video conferencing technology, the process until the final implementation can be time intensive [10]. Thus, taking this step is not always easy and before starting and benefiting from digital transformation, a number of challenges can arise. Challenges that can occur during all three categories classified by [27]. The initiation phase, the execution phase, and the coordination phase. Among them are obstacles like lacking and insufficient IT structures, deficient technical skills, and inadequate business processes. Furthermore, the high risk and the amount of costs are often a challenge many organizations face and have difficulties overcoming them [27]. One of the most comment, but also often not considered one: The unwillingness of people to change, as well as the indifference regarding the necessity for radical change like the digital transformation process frequently requires [28].

Generally, the process of digital transformation comes with different challenges—so far focused on the fourth industrial revolution, associated with the concepts of Industry 4.0, Internet of Things and Web 4.0. Furthermore, the speed of digital changes and the fundamental disruption of business concepts, structures and technologies make the process for many organizations difficult as well [5].

Thus, transforming digitally can be described as "beyond the steady state" —due to its huge disruptive effect on all industries and is seen as a change of business rules

as we know them. Therefore, for organizations to successfully implement digital transformation, they must be able to step outside of their normal operating environment—and further, need also to be able to function in this environment [29]. Correspondingly, not only IT skills and the technical structure are highly relevant for implementing digital change, but also the leadership and the digital agility within an organization is of significant importance. The summary: Digital transformation is about more than just the technology. Instead, radical and cultural changes from within a company are necessary, as well as the willingness to transform past business processes and working methods [22]. (Accordingly, digital transformation is a highly relevant topic that got even more relevant since the beginning of the global COVID-19 pandemic.

3.3 The Impact of COVID-19

Since the outbreak of the pandemic, digital transformations have shown great potential: Not only in form of online education and online working, but also in areas like unmanned deliveries [30]. A successful digital transformation strategy can lead to enhanced competitiveness, productivity, and performance [31]. Accordingly, digital technologies are seen as an appropriate approach to deal with the disruptive changes caused by the COVID-19 crisis [19].

But the necessity of transforming digitally is often not voluntary. Instead, many companies are left with no other choice than implementing new technologies to ensure their survival. Several organizations have been forced to adjust their internal working practices or feeling pressured into selling their products or services through online channels. Thereby is the period to implement these changes regarding digital technologies a lot shorter than usually [5].

Thus, even if digitization and the process of digital transformation are not new phenomena, the associated chances and challenges are constantly changing—and the outbreak of COVID-19 influenced these changes significantly. Many organizations had and have to take these steps despite their previous position or their experience and that in an incredible short time frame. The uncertainty makes it a lot harder to plan ahead, as well as the permanent risk of reduced incomes and sales that do not cover the costs. Furthermore, the pandemic influences the hiring and recruitment process of organizations: The unexpected and fast-acting necessity of transforming digitally, caused a sense of inability to attract talents that are needed for the future development of the company. Not only through the negative impact on the financial resources, but also due to the problematic circumstances of hiring during a global crisis [5].

The solution: Digital transformation. As a result of COVID-19, 76% of businesses plan on long-term IT changes. Furthermore, more than a third of 2021 tech budget will increase due to the influence of the worldwide pandemic [31]. Without a choice, many organizations implement digital transformations that they may not have previously considered necessary. The pandemic shifted the business focus towards a

more digitalized world and has accelerated the digitization process in many companies: Organizations have to improve their digital maturity, because less digital mature companies are more fragile and firms with a high digital maturity are in general more flexible. This is particularly relevant for SMEs which are significantly impacted by the COVID-19 crisis and its impact on the digital transformation [10].

4 Small and Medium-Sized Enterprises (SMEs)

4.1 Definition and Relevance

When talking about SMEs, it is difficult to come up with a single definition. Over the years, a number of attributes were retained, but there is still no agreement. Nowadays, there a different approaches based on the number of employees, the annual turnover and the active balance [33]. One of the reasons for the absence of a unified definition is justified by the factor that two large distinct approaches are used: The qualitative and the quantitative.

The qualitative approach focuses on socio-economic factors which can be divided in different dimensions:

1. The human dimensions, analyzing the behavior of the entrepreneurs and accordingly, focusing on the personalization of the management in SMEs
2. The Bolton report [34] which is based on three different criteria that highlight the personalized and "flat chart" management frequently represented in SMEs:
   a. The aspect of a company that is run by the owners or a personalized management,
   b. A relatively small market share
   c. And the independence of an organization.
3. The multi-criteria approach which focusses on more descriptive aspects—besides the human aspect:
   a. The executives are often relatively non-specialized,
   b. The close relationship between the management, workers, owners and suppliers,
   c. The missing strong positions to negotiate purchases and sales,
   d. The limitation to raise capital and accordingly, being forced to self-finance. [32].

In general, the qualitative approach takes many criteria and several dimensions into account, which makes it hard to operate them when it comes to empirical studies or to enforcing laws or taxes. Whereas the quantitative approach allows a quick and easy identification of SMEs. Based on apparent and measurable element of an organization, SMEs are classified regarding factors like their annual turnover or the number of employees. These aspects are more tangible and make a generalization

easier [35]. Correspondingly, the European Commission has established the first definition of SMEs in 1996 and by now, it includes the following points:

- SMEs have less than 250 employees,
- Their annual turnover is less than 50 million Euros and their annual balance is less than 43 million Euros
- And they fulfill the independent criteria, which means that not more than 25% of capital or voting rights are held by another organization Table 1.

The definition is not mandatory for European countries but they are recommended to establish common characteristics necessary to compare statistics. The problem: Since the approach is solely quantitatively it does not take the multi-dimensional and complex system of SMEs into account and social-economic and other relevant aspects of the qualitative approach get neglected [33] (Fig. 3).

There were estimated to be approximately 25.1 million small and medium-sized enterprises (SMEs) in the European Union in 2018, with the vast majority of these enterprises micro-sized firms which only employed fewer than nine people. A further 1.47 million enterprises were small firms with between 10 and 49 employees and

Table 1 Definitions of SMEs [34] (Based on european community recommendation 2003)

Criteria	Micro-enterprise	Small-enterprise	Medium-sized enterprise
Number of employees	<10	<50	<250
Annual turnover OR	<EUR 2 million	<EUR 10 million	<EUR 50 million
Total balance sheet	<EUR 2 million	<EUR 10 million	<43 million
Independence	Not more than 25% of the capital or voting rights held by one or more enterprises which are not themselves SMEs		

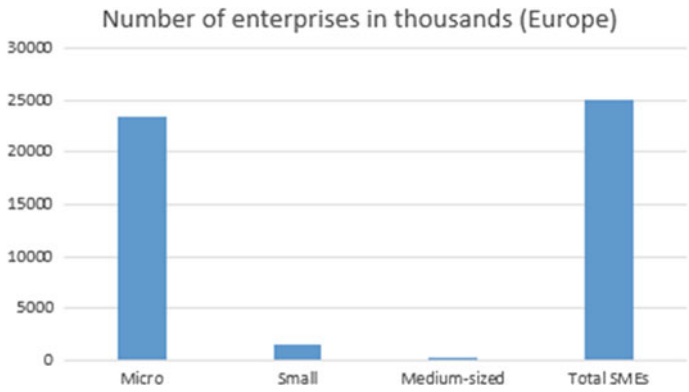

Fig. 3 Number of small and medium-sized enterprises (SMEs) in the European Union in 2018, by size [34]

approximately 236 thousand were medium-sized firms that had 50 to 249 employers [37].

In many countries, SMEs are crucial for the economy, which makes their survival and business continuity so important. Not only do they secure a large extent of jobs, but they are also seen as the backbone of a number economies—like for example in Europe [4]. They are an important part of the economy, but their value to each country varies quite significantly. In Germany, 82% of the country's added values comes from SMEs, while in Malta, 93.1% of value added to the economy comes from SMEs. The average value contributed by SMEs to the economy for the European Union is around 56%. They also employed approximately 70% of the workforce in the European Union during 2018, which are over 97 million people. In Europe's biggest economy, Germany, 19.1 million people were employed by SMEs—7.21 million people by small-sized enterprises alone [37].

In general, SMEs play a key economic role worldwide and accordingly, are a highly relevant research topic. Not only because they are still not uniformly defined and a number of questions is still unanswered, but also due to their unique characteristics and special features.

4.2 Characteristics and Special Features

SMEs are often referred to as backbone of the economy. They represent an essential source of economic growth and play a significant role in the GPD growth, as well as for promoting competitiveness by bringing new products and technologies on the market [33]. Furthermore, SMEs can be considered as vital factor for stimulating innovation, creating job opportunities and poverty reduction [3].

Due to their flexibility and dynamic, as well as their close work with other people, SMEs are often more informal and less bureaucratic than larger organizations. These aspects can support a productive digital transformation because they can adjust more quickly to environmental fluctuation. Since the procedures in SMEs are often more unstructured than in larger companies, they have a wider scope for improvisation and spontaneity [3]. Their dimensions offer them an advantage in the context of globalization and an edge concerning adaptability. On the other hand, SMEs generally have a more limited amount of resources—a fact that can negatively influence the implementation of digital transformation steps. In many cases, their possibilities of gaining resources and gaining external help are limited. Thus, the need of SMEs in the process of digital transformation can vary [20].

This can be especially problematic, since SMEs mostly increase their productivity through finance and investments not only allow the access to technology, but also help to expand the business and ensuring the competitiveness [33, 35 stated that even if the definitions of the general characteristics of SMEs differ globally, they are often quite similar regarding their source of capital: Most SMEs derive their capital from a bank or from a private source—like friends or family from the entrepreneur. Accordingly, they are often more oriented towards personal values instead of solely

focusing on innovation or growth. The goal: Reducing the debt, guaranteeing survival and gaining stability [3].

A number of studies were performed regarding the special characteristics and challenges of SMEs. Among them the analysis from [38] and [40], which both showed quite similar results by identifying four unique challenges and characteristics of small organizations:

1. SMEs lack technical stuff, which makes it hard to implement digital changes and transformations.
2. They have limited access to resources for external interactions what leads to insufficient information, as well as awareness about new technical trends and opportunities.
3. Since SMEs are often dominated by a single owner or a small team, they lack management expertise.
4. Their financial resources are, in many cases, limited. Thereby, the scope for new capital or ongoing investment for new technologies is restricted.

These similarities of the characteristics can make the process of digital transformation challenging. Not only due to the lack of resources, the limited number of employees and the aversion to restructure procedures and business policies, but also because of focusing mainly on survival [3]. To secure the continuing existence, strategic rethinking of the business processes is necessary, as well as gaining sustainable competitive advantages. These depend on the configuration and reconfiguration of resources, which are needed to create new capabilities—and became especially relevant since the beginning of the COVID-19 pandemic [31]. Thus, SMEs do not only maintain the social stability, but also can be a mean to promote technological innovation [30].

5 Digital Transformation in SMEs in Times of COVID-19

5.1 Impact of COVID-19 on SMEs

Worldwide lockdowns and the closing of countless industries and businesses led to many disruptions, including the significant increase of unemployment. The impact of the pandemic is enormous and, in most countries, the GPD has fallen more than ever before. Not only because the introduced restrictions by the government lead to the reduction of business activities, but also due to supply chain disruptions and HR issues. The general flow of goods and services is lastingly interrupted and endangers the profitability of organizations [31].

Since SMEs have limited resources, they are especially threatened by the crisis [11]. In comparison to larger and global companies, they tend to have lower capital reserves and assets, as well as a lower level of productivity [31]. They are generally less resilient and take longer to return to their normal operation after an external

shock or an extreme disruption like the outbreak of the COVID-19 pandemic. This became especially visible after the global financial crisis in 2008, where the decline in demand and the financial distress of SMEs were severe [4].

The interruption of cash flows and the decreasing demand make SMEs vulnerable and put the future of many companies at risk [2]. Not only due to the immediate effects of the universal lockdowns across major economies, but also because of long-term effects of the COVID-19 pandemic. The immediate effects include negative impacts on the upstream and downstream activities, logistical issues and threatening declines on the demand-side—based on employment uncertainties, financial constraints and the incapacity to produce. Furthermore, governmental restrictions and legal limitations forced a lot of SMEs to implement significant changes in their establishments, which required even further financial investments. Thus, in the short-term, financial concerns and liquidity issues are for most SMEs inevitable [4]. Whereas, in the long-term, SMEs should strive to turn these threats into opportunities in form of strategies responses. Correspondingly, the crisis can also be seen as a chance to unfold the full potential and capabilities of an organization [30].

5.2 Chances for SMEs Regarding Digital Transformation During the Pandemic

The COVID-19 pandemic forced many organizations to take actions in many directions. One of this direction is the one towards a more digital business model. The digital transformation of different processes inside a company and is often necessary for surviving the global crisis and even if these changes do not come without a number of challenges, they also can be seen as a chance—especially in SMEs. They can improve the quality of their products or services and develop new strategies—like the promotion of the company through digital marketing. Sales and logistics can be improved by the use of online applications and accordingly, by an intensified promotion. Furthermore, digital skills are necessary for an innovative corporate structure and a sustainable business and future of an organization. On this way, sustainability of a business is generated [2].

Thus, even if the implementation of digital changes can be difficult in the short-term, the process can lead to long-term benefits for SMEs. Due to their size and flexibility, SMEs have the chance to explore new opportunities and plan sustainable business operations [31]. In this respect, the outbreak of COVID-19 can be seen as a driver of digital transformations that have been necessary but never the top priority. Correspondingly, even if causing global health, social and economic problems, the pandemic also creates awareness. Since many companies simply just did not have a choice but to transform, they simultaneously increase their long-term competitive position, as well as their skills and knowledge. A number of different steps can be taken to realize this process.

When promoting products, services or businesses online, the use of social media is a helpful tool. Nowadays, no other medium generates a greater reach and social media is not only a way to create visibility, but also to build an online community and customer loyalty. Furthermore, the cashflow has to be maintained. To manage cash optimally, an online software can be used, which is also really helpful during re-budgeting. Current and future business transactions need to be monitored, as well as the inventory. All these steps are illustrated in the following framework [2] (Fig. 4).

In combination with their tendency to be privately owned and their comparatively flat hierarchical structures, they are more flexible and adaptable than bigger organization which can be especially helpful and beneficial during crisis [4].

This is why the investment in digital technologies is so important instead of only focusing on crucial downstream activities like sales and marketing: The digitalization of internal processes provides new opportunities and increases the efficiency and productivity of SMEs [4] and refers to the process of organization transformation through the adaption of digital technologies. These include digital artifacts,

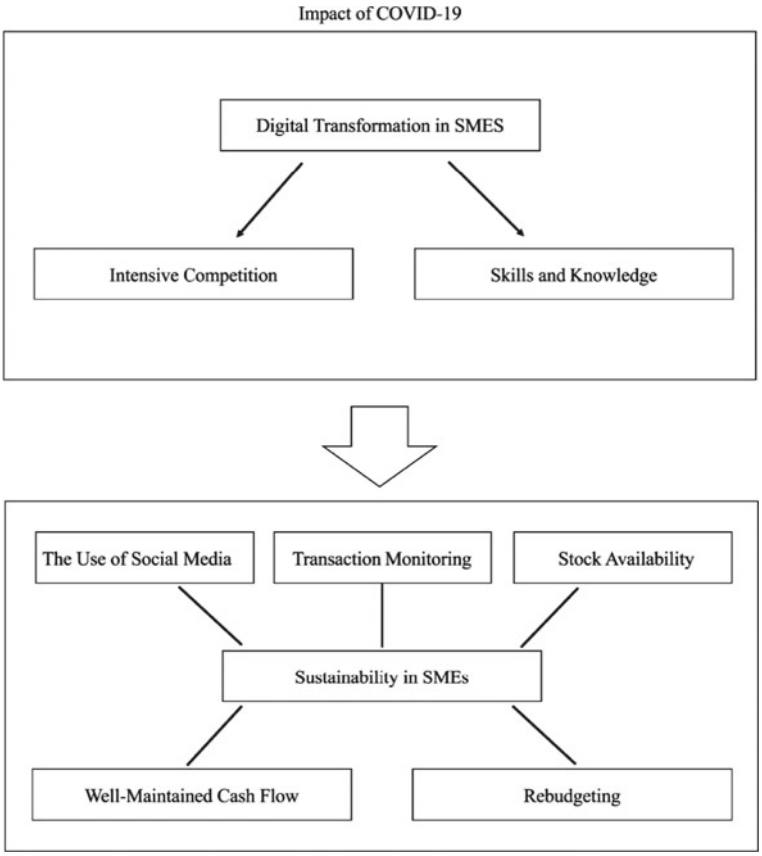

Fig. 4 Impact of COVID-19 on digital transformation and sustainability in SMES [41]

digital platforms and infrastructures, as well as digital business and management models and combine computerized information and communication technologies. The great advantage: The collection of valuable information at low costs, high quantity and through high-speed computing—which can be a helpful tool for sensing and predicting environmental changes to some extent. The accuracy of business analyses improves significant, and opportunities can be identified and exploited more efficiently [30].

Digital transformation can create new value in business models and economic growth in SMEs. Due to the combination of digital and physical resources, the process also builds competitive advantages. To successfully achieve these goals, the right digitalization strategy is necessary and the consisting digital infrastructure has to be tested. It is also important to create the right mindset and common understanding inside of the company and to determine the right leadership. A digital strategy has to be formulated and a digital business center launched—based on gained, developed and discovered knowledge. The goal: The creation of new digital capabilities [11].

One main strength of SMEs: The ability to explore options more rapidly, due to their shorter supply chains and the work on a more local level. The elasticity and fluidity are especially important during the pandemic. Organizations that learn and reflect during this period will be most likely to continue to change after the lockdown—and that in new and innovative ways while generating the long-term survival of the company [9].

Overall, a number of different chances can result from the COVID-19 pandemic for SMEs. On the one side, the chances include aspects relevant for everyone, like the creation of awareness, the drive towards sustainability and the long-term increase of digital maturity to generate a competitive advantage. However, to implement these chances and profit from them, various challenges have to be overcome.

5.3 Challenges that Come with the Implementation of Digital Transformation During a Global Crisis

The outbreak of the COVID-19 pandemic came for many SMEs worldwide totally unexpected. Within an incredibly short period of time, the global economy changed significantly and suddenly, the future of many organizations was uncertain and at risk. Business models and processes had and still have to be adapted, changed and digitalized rapidly and many SMEs were faced with a number of various challenges.

Since SMEs play an important and leading role in the worldwide economy, they are crucial for strengthening the performance in times of crisis where global economic activities are slowing down [35]. At the same time, they are vulnerable to crisis due to their characteristics and special features. Logistical problems arising through disruptions of transportation and labor shortage and the shutting down of various global value chains posed a major problem for many SMEs. Together with the declining demand and the drop of consumer confidence, the simultaneous implementation

of necessary digital changes and transformations can become an insurmountable challenge [4].

This becomes particularly true, when taken various industries and their different restrictions by the pandemic into account. While some sectors can already operate almost fully again or even have made high profits since the beginning of COVID-19, industries like tourism, gastronomy or event planning are still severely limited. In many countries, cafes, restaurants and similar facilities are still closed, accordingly cannot generate revenue and are often dependent on government funding assistance. Thus, even having the possibility or necessity of digital transforming, many companies are still too limited due to restriction to implement and use them effectively [13].

In many cases, the upgrade of production processes is necessary to cut costs and increase productivity in the long-term. Furthermore, upgrades regarding the digital infrastructure are needed—enabling online sale channels, teleworking and other digital changes: At the beginning of the pandemic many SMEs had no supported video conferencing tool, system that could not be accessed out of the home office but also on-side and only worked with processes not able to do remotely [10].

The approach of the maturity model from [25] also poses some challenges for SMEs: Without the severe time pressure created by the pandemic's constraints, SMEs would first rank themselves in terms of digital maturity level before taking any steps regarding the digital transformation process. Since especially more traditional, family-owned and industrially SMEs are ranked fundamentally lower regarding their digital level, they were in many cases neither ready, nor prepared for the necessary changes caused by the COVID-19 pandemic. Thus, they maybe have to take measures that are not appropriate for their level, which complicate the implementation and increase the risk of failing. Together with the fact that digital transformation and especially reaching a higher level of digital maturity can be a time-consuming process, the success of digital changes as short-term reaction during a pandemic lockdown can be questionable [10].

When considering [26] two approaches: The radical approach and continuous improvement, it becomes clear that digital transformation due to the COVID-19 crisis fall in the category of the radical approach, which means larger steps, if not jumps from an organization toward the realization of digitalization are required. This approach comes with an extremely high risk, especially since the whole process of digitalization often is an unknown field for SMEs—in particular with regard to the pandemic circumstances. Thereby, the decision of taking this risk is remarkably challenging and prevents many SME from taking the step towards the necessary digital transformation. Due to the uncertainty of the pandemic situation, this effect is further magnified and the consideration of the time after the pandemic moves further and further into the future.

With view on the different steps that are necessary or recommended for the implementation process of digital transformation, a number of challenges become visible. First, it is not guaranteed that the management is one hundred percent on board with the implementation of the digital changes. Since many SMEs do not have a choice but to adapt, the management does not necessary decide for digital transformation

voluntarily and accordingly, might not be convinced of all the steps which can influence the process and the acceptance of the changes negatively. Furthermore, it is difficult to create a complete and detailed roadmap in such a short period of time and there is a risk that the plans for digital transformation are not well enough thought out—especially with regard to the long-term development of the organization. This is why consultation is often necessary which is hard to realize during a pandemic: Not only due to a high demand, but because the financial resources in SMEs are limited [20].

Since a large part of these necessary and changes requires long-term investments. The problem: SMEs have in general more problems with obtaining loans—even without the circumstances of a worldwide pandemic. Accordingly, many SMEs are dependent on help and financial support, because without them they face liquidity issues and tightened financial constraints. Thus, government support is more needed than ever but with the high number of struggling organizations, the often unclear and confusing forms and the long waiting times make it hard for SMEs to rely on political help [4].

As already mentioned in the theory before, these challenges that can occur during all three categories classified by [27]. The initiation phase, the execution phase and the coordination phase. Particularly in SMEs, insufficient IT structures and deficient technical skills are often found which makes the implementation in all three phases more difficult. Especially since the rapid changes and the time pressure triggered by the pandemic ensures that the individual phases often run consecutively, but simultaneously [27].

In general, digital transformation in SMEs can come with a variety of different challenges—particularly in times of a global crisis. The high number of affected companies makes it almost impossible for the government to provide uniform support and if financial support is received by an organization, it is often only enough to cover the arising expenses. Without this support, digital transformation is not an option for many of the concerned SMEs, even if this would mean a more efficient crisis management and the establishment of a sustainable business development [4].

6 Conclusion

Digital transformation can be a helpful tool to improve the performance of SMEs and can lead to a better response strategy to public crisis like the COVID-19 pandemic. Not only to secure the survival of the company, but also to improve consisting strategies and business process and increase the efficiency. Thus, even if the outbreak of a worldwide crisis caused a lot of challenges and problems—especially for SMEs, the immediate requirement of changes and necessary adjustments can also be seen as a chance to implement new concepts and digital strategies.

With regard to the research questions, this makes it hard finding a concrete and clear answer. Not only because it depends on the particular circumstances of each SME, if the digital transformation as consequence of the COVID-19 pandemic is

rather a chance or a challenge, but also due to the fact that in most cases, the one side does not come with the other. Since the changes are in most cases indispensable, SMEs can use this liability as chance. Not only to generate a sustainable future and long-term development of the organization, but also as short-term solution as direct consequence to the outbreak. Due to their special features and characteristics, SMEs can react more flexible to changes and are able to explore options more rapidly. But these rapid changes to do come without a risk.

Accordingly, various facts can be summarized: First, the outbreak of the global COVID-19 crisis creates awareness with regard to digital transformation. The high relevance of the topic became clear in various SMEs that classified digital changes not as important and preferred more traditional working methods in the past. Through the necessary implementation, like working remotely, digital information provision and the digital exchange within the company, a more flexible and more adaptable working environment was created in many organizations. Thus, digital transformation in SMEs during the COVID-19 pandemic can be considered as an effective crisis management and prepares the ground for a sustainable and long-term survival of their establishment.

However, without sufficient financial resources this step is not possible—which is also the most significant challenge for SMEs. Due to the financial constraints that have resulted for many companies from the crisis, resources for necessary digital transformations are limited and the possibilities for financial support are hard to come by. Because governments around the world were also caught unprepared by the crisis, uniform regulations and targeted emergency aid are rare and often take a long time to arrive at their destination.

Overall, it can be said that SMEs are particularly influenced by the pandemic due to their smaller size, their limited financial resources and the frequently lower level of digital maturity. Since they are a large part of the global economy, their severe impairment has far-reaching effects. This is why it is of significant importance to maintain the unique SME culture and to support their digital transformation—especially in times of crisis. For this, an easier access to financial sources is necessary. Not only to encourage the digital development in smaller organizations, but also to minimize global economic disadvantages after the end of the pandemic.

Furthermore, this research has some limitations: First, it does not analyze the differences regarding the impact of the pandemic on SMEs and large cooperation, due to the fact that the characteristics of large enterprises are not considered. In addition, most of the articles this paper is based on view SMEs as traditional and often family-owned companies with a low level of digital maturity. Therefore, the whole tech-savvy start-up culture including particularly young organizations with strong technical knowledge is not taken into account. Another limitation is the use of models developed before the pandemic outbreak. Since then, circumstances have changed considerably, and it is questionable to what extent the factors and dimensions of the models still apply. Thus, further investigation is necessary to close the research gaps and lead to more generalized findings.

All in all, the economic consequences of the COVID-19 pandemic are a highly relevant topic—particularly regarding the digital transformation. Both topics will

have a far-reaching influence on the economy in the future and their positive and negative effects will impact SMEs and their business models and process in the long-term. Maybe even more than they do now.

References

1. Savic, D.: COVID-19 and Work from Home: Digital Transformation of the Workforce. Grey J. (TGJ) **16**(2), 101–104 (2020)
2. Winarsih, Indriastuti, M., Fuad, K.: Impact of Covid-19 on digital transformation and sustainability in small and medium enterprises (SMEs): A conceptual framework. Complex, intelligent and software intensive systems, pp. 471–476 (2020)
3. Kamal, E.M., Flanagan, R.: Key characteristics of rural construction SMEs. J. Constr. Dev. Ctries. **19**(2), 1–13 (2014)
4. Juergensen, J., Guimón, J., Narula, R.: European SMEs amidst the COVID-19 crisis: assessing impact and policy responses. J. Ind. Bus. Econ. **47**, 499–510 (2020)
5. Almeida, F., Santos, J.D., Monteiro, J.A.: The Challenges and Opportunities in the Digitalization of Companies in a Post-COVID-19 World. IEEE Eng. Manage. Rev. **48**(3), 97–103 (2020)
6. Sweeney, Pete, Yawen Chen. n.d.: China makes Double-Digit growth look disappointing: Reuters. Retrieved May 13, 2021 (https://www.reuters.com/breakingviews/china-makes-double-digit-growth-lookdisappointing-2021-04-16/)
7. Papadopoulos, T., Baltas, K.N., Balta, M.E.: The use of digital technologies by small and medium enterprises during COVID-19: Implications for theory and practice. Int. J. Inf. Manage. **55**, 102192 (2020)
8. Eurostat.: Eurostat news release. April 2020. Available at: https://ec.europa.eu/eurostat/documents/2995521/10294708/2-30042020-BP-EN.pdf/526405c5-289c-30f5-068a-d907b7d663e6 (2020)
9. Fitzpatrick, Matt, Isha Gill, Ari Libarikian, Kate Smaje, Rodney Zemmel.: The Digital-Led recovery from COVID-19: Five questions for CEOs. Mckinsey digital:9. (2020)
10. Fletcher, G., Griffiths, M.: Digital transformation during lockdown. Int. J. Inf. Manage. **55**, 1–3 (2020)
11. Fitriasari, F.: How do Small and Medium Enterprise (SME) survive the COVID-19 outbreak? J. Inov. Ekon. **5**(2), 53–62 (2020)
12. Tran, B.X., Nguyen, H.T., Le, H.T., Latkin, C.A., Pham, H.Q., Vu, L.G., Le, X.T., Nguyen, T.T., Pham, Q.T., Kim, N.T., Nguyen, Q.T., Ho, C., Ho, R.: Impact of COVID-19 on economic Well-Being and quality of life of the vietnamese during the national social distancing. Front. Psychol. **11**, 1–9 (2020)
13. McKeen, M., Stuckler, D.: If the world fails to protect the economy, COVID-19 will damage health not just now but also in the future. Nat. Med. **26**, 640–648 (2020)
14. World Health Organization: Coronavirus disease (COVID-19) Weekly epidemiological update and weekly operational update. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports (2021)
15. Murugan, S., Rajavel, S., Aggarwal, A., Singh, A.: Volatility, uncertainty, complexity and ambiguity (VUCA) in context of the COVID-19 pandemic: challenges and way forward. Int. J. Health Syst. Implement. Res. **4**(2), 10–16 (2020)
16. Bennett, N., Lemoine, G.J.: What VUCA really means for you https://hbr.org/2014/01/what-vuca-really-means-for-you (2014)
17. Riley, C.: 60 million Europeans could suffer furloughs, layoffs or wage cuts. https://edition.cnn.com/2020/04/19/business/europe-jobs-coronavirus-mckinsey/index.html (2020)
18. Business plans resulting from COVID-19 (https://swzd.com/resources/state-of-it/)

19. Priyono, A., Moin, A., Putri, V.: Identifying digital transformation paths in the business model of SMEs during the COVID-19 pandemic. J. Open Innov.: Technol., Mark., Complex. **6**(4), 1–22 (2020)
20. Ulas, D.: Digital transformation process and SMEs. Procedia Comput. Sci. **158**, 662–671 (2019)
21. Schallmo, D., Willams, C.A., Boardman, L.: Digital transformation of business models-best practice, enabler, and roadmap. Int. J. Innov. Manag. **21**(8), 1740014 (2018)
22. Leipzig T. von, M. Gampa, D., Manz, K., Schöttle, P., Ohlhausena, C, G., Oosthuizenb, D., Palma, K. von Leipzig: Initialising customer-orientated digital transformation in enterprises. Procedia manufacturing, 8, pp. 517–524 (2017)
23. Poniszewska-Maranda, D., Kaczmarek, N., Kryvinska, F., Xhafa : Studying usability of AI in the IoT systems/paradigm through embedding NN techniques into mobile smart service system, computing, **101**(11), pp. 1661–1685. https://doi.org/10.1007/s00607-018-0680-z
24. Fedushko, S., Ustyianovych, T., Gregus, M.: Real-Time High-Load infrastructure transaction status output prediction using operational intelligence and big data technologies. Electronics **9**(4), 668 (2020). https://doi.org/10.3390/electronics9040668
25. Azhari, P., Faraby, N., Rossmann, A., Steimel B., Wichmann K. (2014): Digital transformation report. neuland GmbH & Co. KG., Köln
26. Davenport, T.H.: Need radical innovation and continuous improvement? Integrate process reengineering and TQM. Plan. Rev. **21**(3), 6–12 (1993)
27. McAffee, A., Ferraris, P., Bonnet, D., Calméjane, C., Westerman, G.: Digital transformation: A roadmap for billion-Dollar organizations, MIT sloan management (2011)
28. Albrecht, J.: Digitale transformation: Herausforderungen f˙ȣr unternehmen im B2C Bereich. Hamburg: dissertation (2015)
29. Bessant, J., Lamming, R., Noke, K., Phillips, W.: Managing innovation beyond the steady state. Technovation **25**, 1366–1376 (2005)
30. Guo, H., Yang, Z., Huang, R., Guo, A.: The digitalization and public crisis responses of small and medium enterprises: Implications from a COVID-19 survey. Front. Bus. Res. China **14**(19), 1–25 (2020)
31. Papadopoulos, T., Baltas, K.N., Balta, M.E.: The use of digital technologies in small and medium enterprises during COVID-19: Implications for theory and practice. Int. J. Inf. Manage. **55**, 1–4 (2020)
32. Spiceworks Ziff Davis: The 2021 state of IT: The annual report on IT budgets and Tech Trends. https://swzd.com/resources/state-of-it/ (2021)
33. Robu, M.: The dynamic and importance of SME in economy. USV Ann. Econ. Public Adm. **13**(1), 84–89 (2013)
34. Wtterwulghe, R.: The SME: A human enterprise. Edition of Boeck (1998)
35. Mohamed, M., Asmaa, M., Ichrak, A., Yousef, R.: The issue of the definition of moroccan SMEs and different approaches. J. US-China Public Adm. **10**(5), 488–498 (2013)
36. Journal of the European Union L 124, p. 36, 2003 is the sole authentic basis for determining the conditions regarding qualification as an SME.
37. Clark, D.: Number of small and medium-sized enterprises (SMEs) in the European Union in 2018. https://www.statista.com/statistics/878412/number-of-smes-in-europe-by-size/ (2021)
38. Nooteboom, B.: Innovation and diffusion in small firms: Theory and evidence. Small Bus. Econ. **6**(5), 327–347 (1994)
39. Rothwell, R., Zegveld, W.: Innovation and the small and medium sized firm: Their role in employment and in economic change. Frances Printer, London (1982)
40. Sexton, M., Barrett, P.: Appropriate innovation in small construction firms. Constr. Manag. Econ. **21**(6), 623–633 (2003)
41. Winarsih, Indriastuti, M., Fuad, K.: Impact of Covid-19 on digital transformation and sustainability in small and medium enterprises (SMEs): A conceptual framework. complex, advances in intelligent systems and computing, vol 1194. Springer, Cham. (2021)

Artificial Intelligence in Human Resource Management: Personnel Marketing and Recruiting

Antje Lüersmann

Abstract In times of a shortage of skilled workers, companies must exhaust all means and ways to attract the best employees. Recently, the potentials arising from the use of Artificial Intelligence (AI) have come into focus. Various experts are calling for the intelligent use of digital tools in Huma Resource (HR) work—the keyword is Smart HRM. There are many indications that AI can make a significant contribution to recruiting, employee retention, onboarding and the automation of administrative tasks. This article examines the opportunities and challenges of using AI with a special focus on the areas of Personnel Marketing and Recruitment.

1 Introduction

In a study conducted by Oracle and Future Workplace, which surveyed more than 8,000 responsible HR managers in over ten countries, the authors conclude that significant operational and strategic potentials arise from the use of AI in HRM [1]. In the study, more than 80% of HR managers state that it is becoming increasingly difficult to keep pace in HR in view of the rapid technological development. There is consensus among experts that innovative technologies are changing HR-Management (HRM) with a high degree of dynamism [2]. The increased use of AI and related technologies affects the interaction between companies and employees in various ways; this is particularly evident concerning the design of recruiting processes and the automation of HRM activities [3, 4].

Up to now, AI has mainly been used in industrial and high-tech contexts, but more and more people are realising that AI-based systems can also make a significant contribution to HRM. The number of authors calling for a rethink in HRM has increased significantly in recent times [5]. Partially intelligent solutions are already being used in HRM today. Technologies such as Big Data and Deep Learning (DL)

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contribute to the optimisation of coordination and cooperation in companies [6]. In the past, the implementation of personnel information systems has led to significant cost reductions in HRM activities, especially in recruiting [7]. They also make a significant contribution to employee appraisal [8].

However, the opportunities and challenges of using AI in HRM have been rather little researched so far, not least because the development of the corresponding technologies is progressing rapidly. The majority of scientific publications are limited to theoretical descriptions and focus on the potentials. This article attempts a critical analysis considering the subscope of Personnel Marketing and Recruiting.

2 Background

HRM is subject to dynamic change processes, which are caused in particular by the increasing use of innovative technologies [2]. In this context, the use of AI technologies is said to have significant potential [9]. There were many indications that the interaction of HRM and AI would result in advantages in the interaction between companies, employees and potential employees. Various experts point to the potentials that arise for the automation of HRM activities [3, 4].

With increasing technification and the increased use of modern technologies, there are not only changed potentials, but rather this leads to profound changes in HRM processes; not only do interactions and communication change [5], but rather this also leads to far-reaching changes in organisational structures and work processes [9]. The potentials that arise from the use of digital service platforms and bots based on AI are often elaborated [10]. Intelligent solutions in particular have the potential to revolutionise traditional HR functions [5].

In this context, one encounters various technologies that mutually benefit each other and, through problem-focused interaction, make coordination and cooperation more efficient—especially across departmental and company boundaries; DL algorithms, Smart Objects and the Internet of Things (IoT) are mentioned first and foremost in this context [6]. New IT technologies are seen as having significant potential in various HR areas, especially for optimising and reducing the costs of HRM measures, specifically, for example, the automated assessment of applicants [6, 11]. Other authors emphasise the potential in the assessment of employees [8, 12].

The effects that result from the use of modern IT technologies have long since been examined not only in relation to companies or sectors, but increasingly also in international contexts [13, 14]. The main drivers of this development are likely to be the increasing globalisation of business activities and the formation of monopolies in various industries. It is shown that the increasing implementation of e-Recruitment, e-Training or e-Competence Management has a positive effect on HRM-specific tasks [15]. These positive effects can be seen in locally active companies as well as in international players [7].

Various studies prove the positive effects that result from the use of computer-based functions; process planning, for example, benefits from this because a lot of

processes can be automated and the process speed can be significantly increased [16, 17]. Technological progress can be seen in particular as an enabler for diverse improvements in the structuring of HRM tasks, the design of working conditions and the optimisation of employee training [18]. HRM activities benefit from another aspect: modern IT technologies are said to have significant potential in the area of Knowledge Management [19].

2.1 Relevant Technologies

Experts widely agree that algorithm-based decision-making systems in particular will profoundly change HR work of the future [20], despite significant concerns about the results that digital systems deliver—see 'Weapons of math destruction' [21]. It is not a new insight that the use of new technologies is ambivalent [22]. Backhaus points out in this context that the use of technologies, which can also be used for employee monitoring and evaluation, experience low acceptance among the workforce and cognitive-emotional stress [23].

Despite various negative aspects and unresolved ethical and legal questions, most authors emphasise the potential of various technologies. The discussion is particularly dominated by the two aspects of AI and Machine Learning (ML) [24]. However, there is still a wide gap between aspiration and reality in the use of AI in HR; some authors speak of 'substantial gaps' [25]. It also becomes clear that there are significant know-how gaps on the part of HR managers and that the 'Task-Technology-Fit' often does not correspond to management's wishful thinking [26].

However, experts and practitioners are far from agreeing on where the most significant potentials exist. Some authors see the greatest development potential in analytical tasks [27]. However, AI-based HRM applications are also subject to certain limitations. Gärtner prefers the term 'SmartHRM' to highlight the use of intelligent tools, but at the same time makes clear that "machines [can] only be used effectively for certain (partial) tasks" [28]. The suitability of AI and ML techniques depends on the specific application context. In this context Table 1 summarises the strengths and weaknesses of various AI algorithms as examples.

Basically, it can be seen that although IT technology provides various tools, their use is highly dependent on the tasks to be managed. The consequence of this is obvious: AI is by no means a 'panacea' that provides the right answer for all HR issues, but rather the use of the instruments must be chosen specifically. The choice of technologies is therefore critical to success: Only if the optimal AI tool is used for specific problem solutions can the technology realise its potential. Inappropriate use tends to have negative effects.

Table 1 Strengths and weaknesses of AI technologies and algorithms (adapted from [29])

Technology	Strengths	Weaknesses
Linear regression	Extraction of relevant relations from data sets	Analysis and modelling of non-linear correlations, multicollinearity
Logical regression	Calculation of probabilities of occurrence, modelling options	Outliers, multicollinearity, analysis of temporal data
Decision trees	Analysis of non-linear correlations of different data types, modelling and visualisation	Considered to be less robust. Analysis of variable data
Convolutional neural networks	Analysis of unstructured data with geographic correlation. Pattern recognition. Big data analysis	Coping with different tasks, analysing contradictory data
Recurrent neural networks	Analysis of unstructured data with temporal correlation. Identification of basic patterns	Managing different tasks, analysing conflicting databases, structured data and image files

2.2 Smart Personnel Work

If one follows the premise that the use of AI technologies will fundamentally change HR work, the question immediately arises as to how analytical and automating functions can be optimally used along the HR value chain. The use is to be discussed in particular with regard to the five central HR functions:

- Personnel marketing and recruitment.
- Staff planning and deployment.
- Performance Management.
- Human resource development.
- Staff retention and release.

Specific application possibilities arise for each of these activities, see Fig. 1.

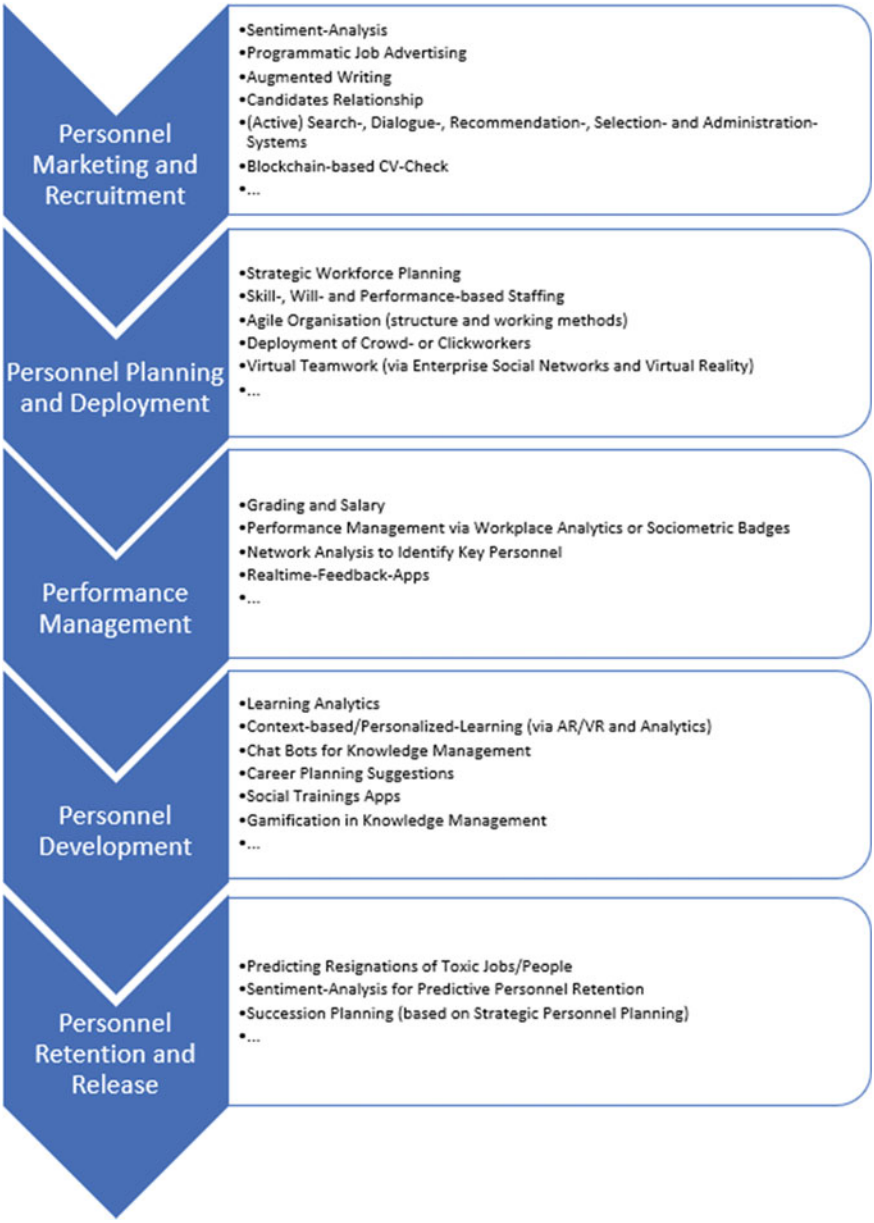

Fig. 1 The use of various AI technologies along the HR value chain (according to [33])

3 Personnel Marketing and Recruiting

Personnel Marketing and Recruiting are two central tasks in HR work.

3.1 Personnel Marketing

In marketing, the aspects of profiling and acquisition in the direction of potential employees essentially play a significant role; in addition, the aim of Personnel Marketing is to work out the retention effect of companies for existing employees [30].

In this context, **Sentiment Analyses** make an important contribution to objectively depicting the employer image [31]. Within the framework of such analyses, postings in social networks in particular that relate to the evaluation of employers or the mood at the workplace can be analysed automatically. Modern IT technologies are also able to derive forecasts from existing data and data analysis [32]. It is also significant that reverse effects arise between corporate reputation and employee satisfaction [27]. The collection of relevant information is usually carried out by so-called Crawlers, which evaluate social media and portals, such as Twitter, Facebook, Glassdoor or kununu, but also internal company data, such as mails, posts on the intranet or employee surveys up to video and meeting recordings [33–35].

In practice, special analysis tools use a mix of different technologies. So-called Multimodal Sentiment Analyses use lexicons, Convolutional Networks (CNN), Long Short Term Memory Networks (LSTM), Classification Algorithms and Support Vector Machines [36]. Sentiment Analyses offer a wide range of applications in HR. For example, they can serve as a 'barometer of mood' [36], capture employees' emotions [37] and evaluate feedback on training programmes [38, 39].

The automatic purchase and sale of advertising space for job ads (**Programmatic Job Advertising**) is based on user data as well as 'historical' movement data of internet users. Using profile data, website visits and click patterns, the software predicts how and where a company's advertising campaign should best be placed and also monitors success, e.g. via click rates and applicant numbers. Different types of targeting are distinguished, such as demographics and/or geography. Text-mining methods can also be used to display job ads based on keywords in blogs or other online sources [33].

Based on the same techniques, **Dynamic Job Advertisements** can be placed. These change their appearance depending on the candidate, up to and including real-time adaptation, based on current user behaviour on the internet. LinkedIn, for example, personalises and dynamises the ads based on the information in the user profiles [33].

Augmented Writing uses text mining and ML algorithms to 'optimise' job postings for diversity and inclusion, making them more interesting for the respective target group. The words used are analysed and suggestions for other wordings are

made. The aim is to ensure that the job advertisement is not only aimed at men, e.g., but also at women, in order to avoid gender bias. The tone and difficulty of the words used are also taken into account [40].

In this context, Gärtner completes with a hint on tools that help **Individualise the Job Offer**, on the one hand in terms of salary, and on the other in terms of other offers that are intended to encourage the applicant to sign [33].

Especially in times of a shortage of skilled workers, companies invest a lot of energy in building personal relationships with potential employees. This is where **Candidate Relationship Management** comes into the picture [41]. Based on matching procedures (see Sect. 3.2), the aim is to maintain long-term contacts with candidates and applicants via talent pools, regular notifications of company and industry news, employee-recruit-employee concepts, etc.

In the context of **Advocacy Marketing**, not only should existing employees become recruiters by recommending jobs to others, but a further matching between content from the work environment and jobs should be created, for example by linking a job advertisement with a success story from a past customer project, whose content matches the job description, in social media [33].

3.2 Personnel Recruiting

In recruiting, everything revolves around the question of how a vacant position in a company can be optimally filled. HR managers are therefore faced with the challenge of finding the optimal requirements-person-fit [42].

(Partially) automated **Search, Recommendation, Dialogue and Selection Systems** have been used for some time [39, 43]. In many cases, special modules are already integrated in corresponding company systems. In this context, Gärtner points to the problem of 'inflation in job titles and competences' [33]. Here, the use of self-learning systems promises significant potentials, as they are capable of factual differentiation.

In this context, **Active Sourcing** is becoming increasingly important, in which companies identify and actively approach interesting candidates themselves; here, too, experts recognise significant potential for process optimisation using AI [44]. In practice, various technologies and algorithms are used. Sourcing is an application that is highly automated. A recruiter typically enters certain characteristics that a desired candidate should have (both with scales or standardised items as well as open input options in the sense of keywords). In the next step, the programme identifies candidates with a matching profile. In contrast to simple personnel search engines on platforms such as monster.de or the social network XING, the search using AI is much more complex. It also includes searches on other websites and from homepages or newsletters, but above all job advertisements on different portals on the internet [45].

Search systems follow links on internet pages, collect the information they contain and analyse it (Crawling, Scraping, Parsing) [33]. For example, the name, work experience and job preferences on a person's profile page in business networks

such as XING, LinkedIn or Github can be read out. Studies show that for the LinkedIn network, e.g., the Generalised Linear Mixed Model (GLMix), a Logistic Regression, leads to an above-average fit between the displayed job advertisement and the candidate preferences [29].

Recommender systems are another important technology in the field of automated recruitment [46]. These systems work both ways, either by suggesting a suitable job to the job-seeking candidate or by suggesting a suitable candidate for a vacancy to the recruiting department of the searching employer. This is where techniques such as 'Smart Matching' come into play, based on Knowledge Representation techniques that consider not only individual words, but whole sentence structures and meanings, and thus interpret texts [33, 43].

Digital Dialogue Systems applying in form of chatbots are also considered another important technology [43]. These are programmes that communicate automatically with applicants, whereby the complexity varies greatly depending on the quality of the programming. As so-called *text- or speech-based bots*, they are able to identify and analyse input of text or speech by a user in order to subsequently output a suitable response. As *rule-based information systems and dialogue systems*, bots work through pre-structured questions and answer schemes and can only act as the databases behind them allow. Typically, bots communicate via messengers on the website of a job portal or are displayed on a company homepage. With many tools, applicants enter certain information into the messenger, whereupon the messenger provides suitable answers that lead the applicant to a suitable job. Conversely, employers can do the same. This should both minimise the processing burden for applicant management and improve matching between job seekers and potential employers. It can also be combined with existing profiles including relevant information from applicants and companies in a suitable way [33, 45, 47]. *AI-based bots* can learn through Artificial Neural Networks (ANN) techniques based on experience and adapt question–answer behaviour.

Selection Systems serve the 'assessment and prediction of occupationally relevant variables for the assessment of aptitude' [33]. A wide variety of AI methods can be used for this purpose. One example is automated procedures in the sense of *pre-screening* prospective candidates before manual selection. For example, CVs can be automatically searched for important characteristics and thus also take exclusion criteria into account, web-based personality or creativity tests can be used, and even online games [33]. At the same time, scorings can be created that automatically pre-screen a large number of applicants and then classify the most suitable prospects and graphically prepare the result. This can save time, financial and human resources. Learning processes in the sense of DL lead to the system absorbing previous experiences and taking them into account for improvements of the process in future runs, which can become a continuous cycle [42, 48].

Online Assessments are also increasingly being used [49]. The aim is the so-called self-selection or external selection. In the former, intelligence tests, career orientation games or personality inventories are used, combined with the question of whether the candidate would even like to apply to the company him/herself [49]. The

aim of external selection is to identify the most suitable applicant. Games are also increasingly used here, in the form of game-based assessments or recruitments [49].

Another area of application in pre-screening can be found in the next step—large companies such as IKEA with its "Robot Vera" programme are already able to conduct automated *telephone interviews* with prospective applicants and make an automated pre-selection of applicants on this basis. In the process, sophisticated programmes can also analyse para-verbal information using AI and accompanying DL and process it in a decision-oriented manner in a next step. For example, key terms can be determined, but also the tone of voice, the quality of speech and the speed of answers [50].

When a *video conference* takes place, appropriately developed applications can also analyse features such as facial expressions, gestures and body language as a whole for both positive and negative aspects in relation to the vacancy. For example, a straight posture can be classified as positive, while hectic, fast body movements can be classified as negative [51].

Figure 2 summarises the changes in recruiting and sourcing due to digitalisation.

After the **Pre-selection** has been **completed**, AI can be used to send e-Mails to the applicants with information about the results and the next steps. For example**, Rejections** can be sent automatically to applicants who have been eliminated or, in the case of a positive pre-selection, an **Appointment** can be made for the next step of the interview [51]. It should be mentioned that the information gained from the pre-selection can not only be used for an initial assessment and pre-selection of applicants, but can also be used again in the following steps of the personnel selection process—or the knowledge gained so far can be used [42, 48].

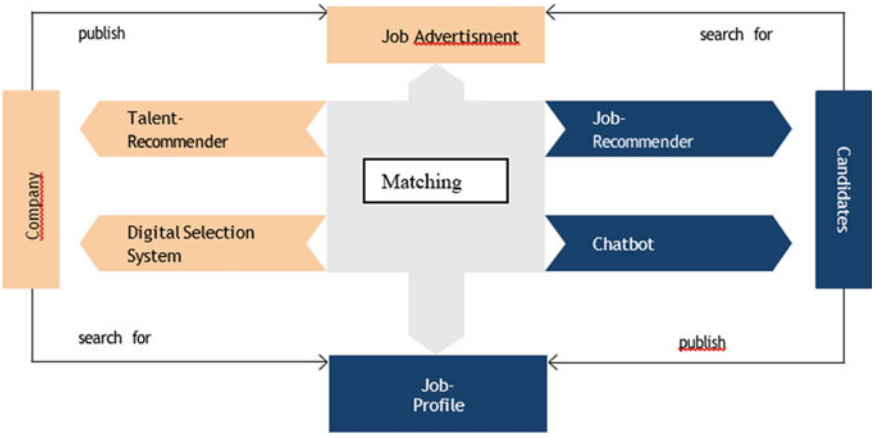

Fig. 2 Changes in recruiting and sourcing [43]

4 Opportunities and Challenges

In the following, based on the previous explanations, general opportunities and challenges of the use of smart technologies in HRM will first be worked out, in order to subsequently work out relevant challenges in the area of Marketing and Recruiting, in addition to the general aspects already mentioned in Sect. 2.1.

4.1 Opportunities and Challenges of the Use of AI in Human Resource Management in General

Opportunities

A first advantage arises with regard to the use of resources within the framework of HRM in terms of the input–output ratio. The use of AI also brings with it a high degree of automation, which can also lead to financial, personnel and time savings. Specifically, paid working time for staff to be deployed can be saved throughout the recruitment process. AI can take over numerous tasks that were performed by HR managers, and in some cases do so much more quickly and efficiently. However, this requires sound programming and adaptation to the prerequisites and needs of the specific company [52]. For example, in 2019, Unilever claims to have saved 100,000 h of interview time and around $1 m in costs through automation in the area of recruiting alone, and also to have reduced the time between approaching and hiring applicants from four months to four weeks [53].

Overall, in addition to increased efficiency, increased effectiveness is also possible. A tool based on AI can potentially carry out processes not only faster, but also more error-free. This means that there is no fatigue effect and there is also less confusion. Human sources of error can therefore be avoided here. In this context, processes can also be simplified [42, 52].

The resources freed up can still be used to refine the process elsewhere, where human involvement seems more purposeful and the possibilities for automation are less pronounced—also for other areas such as human resource development [52].

Furthermore, the use of AI also generates numerous data. These are both generated within the framework of People Analytics and Personnel Controlling and used by them. This offers numerous possibilities for further use and evaluation of the data and linkage with other data sets within the framework of a company's data warehousing and thus broadens the basis for decisions that are made on the basis of the available information in the company. This data can also be used for systematic, IT-supported Knowledge Management. Elements of AI can be used for analysis and evaluation [52, 54].

Another advantage is that the use of AI can help avoid discriminatory motives in personnel selection. For example, it typically does not pay attention to the name or ethnicity of employees. In this way, stereotypes that are detrimental to performance are left out of the equation. However, this connection is quite controversial. On

the contrary, some publications conclude that discriminatory patterns can influence selection using algorithms and thus even have negative effects [55, 56] (see below, Challenges).

Challenges

A first aspect is the issue of Data Protection. Especially in the legal scope of the European Union, there are manifold regulations that restrict the processing and use of Personal Data to certain purposes and times or prohibit them altogether. In the event of violations, organisations in particular may be subject to severe penalties, but also legal consequences with financial uncertainties, which represent a risk that should not be underestimated, especially for small and medium-sized enterprises.

If the autonomous decisions of an Algorithmic-Decision-Making (ADM) system are not comprehensible, this is critical from a legal perspective. The provision of Section 22 of the EU Data Protection Regulation prohibits subjecting individuals to an automated decision that then has legal effect. This would be the case, for example, with an automated test or chatbot if the selection decision would directly lead to an employment contract. As a consequence, the assessment of an applicant by an ADM system is only permissible for the preparation of the decision by a human being. However, mere scoring or profiling for decision preparation does not fall under Art. 22(1) EU GDPR and is permissible [57].

In this context, the company must also pay attention to the protection of data from unwanted external access. This addresses the issue of cyber security. Suitable firewalls, virus protection programmes, but also anti-hacking software must be used so that the partly sensitive data does not fall into unauthorised hands and is misused for industrial espionage, e.g. In addition to legal consequences, this can also lead to a loss of image for the company [58].

Programming and customising tools that use AI is relatively cost-intensive on the one hand and requires expertise on the other. Even if standardised solutions are available, they need to be adapted to the company. Particularly when external service providers are used, the costs can be quite high. While this is easier for large organisations and is also typically done in-house, small and medium-sized enterprises usually have significantly fewer resources or do not generally have their own IT or HR department.

The question generally discussed is whether machine selection is better than human selection? Should companies leave the selection decision to machines or to humans? Thus, there is a divided understanding of what "better" means. In addition to the classic quality criteria such as validity, objectivity and reliability, other aspects such as fairness, transparency, traceability, controllability, user acceptance and costs are often taken into account in order to decide which procedure is "better". However, such aspects already touch on value concepts.

First of all, it can be argued that machine selection is reliable, objective and without bias [49], since personnel selection by algorithms is always the same for all test participants and thus there are no unconscious biases, prejudices or discrimination based on gender, skin colour, origin, language, age, etc. The same applies to the selection of candidates. However, it is pointed out in this context that biases always

occur in AI-based evaluations [59]. The problem of misinterpretation and bias has only recently been the subject of increased scientific discussion [60, 61]. However, no generally valid predictions can be made regarding possible biases, as these depend in particular on the database, the analysis algorithms and the learning processes of the AI [62]. The danger of bias remains, because other data also provide information about these variables and the training data itself can be biased. For example, the first name of an applicant can usually be used to draw conclusions about gender, and the place of residence can be used to draw conclusions about sociomaterial status. Since ML algorithms search for patterns, inequalities can be reproduced if the training data show structural biases and these are not corrected ("bias in, bias out") [42, 62].

The context from which the training data comes is central to what the system learns (professional texts versus error-prone texts in terms of grammar and/or spelling, e.g. newspaper articles versus posts on Twitter). The language itself must also be embedded in the socio-cultural background and checked for situational conditions [63].

In particular, the use of ANN/DL results in so-called black boxing, i.e. it is not clear how exactly the algorithms used process the data and ultimately arrive at decisions [64].

For applicants, but also for companies, there is another black box: the algorithms of third-party providers, e.g. in the form of social networks or job platforms, which play an important role especially for recruiting. For example, a 2019 study analysed display and click-through rates from over 191 countries and from several platforms (including Facebook, Instagram, Google Display Network) to find out whether women were less likely to be shown maths and science jobs there. This was the case, but could not be attributed to biases in the data set, but rather to the pricing mechanism of social networks, which prices the display of an ad for women higher than for men [65].

4.2 Challenges of the Use of AI in HRM in the Field of Personnel Marketing and Recruiting

In the following, various aspects will be further examined by way of example, without, however, claiming to be exhaustive.

Sentiment-Analysis

- With regard to the aspect of data protection, care must be taken to ensure that the data collected is anonymised, even if it is "only" a matter of finding out the mood of a group as a whole and not of individual employees [33].
- If Sentiment Analyses only roughly distinguish between positive and negative attitudes and do not capture semantic nuances or the actual meaning behind what is said, the complexity and context sensitivity of linguistic expressions are only partially covered [33]. Thus negations ("not … good") and so-called ‚valence

shifters', where what is meant is the opposite of what is said/written, or irony, sarcasm and rhetorical questions, can lead to shifts in the evaluation of what is said. Domain Knowledge is also necessary for text or language analysis [66].

- Sentiment models must consider more than just individual words and, if necessary, take into account further situational features such as the time of the utterance, emotion and the emotion carrier [66]. The situational triggers of a sentiment are only approximately known. What triggers an employee to make a positive or negative utterance—so-called intrapersonal or external events—can then be taken into account in some cases, e.g. if texts have a timestamp and this can be assigned to an event, such as in the case of emails sent directly before or after a newspaper report about the employer [33].

Augmented Writing

- Can remove (also potentially) discriminatory elements and, for example, prepare advertisements in such a way that more women will apply.

Active sourcing

- It should be noted that neither the accuracy, completeness or timeliness of the profiles searched or displayed can be guaranteed by the tool used. Nor can the actual suitability or interest, including willingness to change or move, of potential candidates be presumed.

Recommender

- How accurate the recommendations are can rarely be scientifically tested, as the companies do not disclose their algorithms and do not participate in comparative tests [29, 33].
- If a system recommends some candidates and not others based on the automated matching of job requirements and qualification profile, then this is—if the applicants are proposed to the recruiter for further processing—at least a pre-selection or a final selection—if rejections or invitations are sent directly and automatically. Here, particular care must be taken to reduce or avoid 'bias' in personnel selection decisions.

Voice or video data

- Criticism of automated selection systems is directed primarily at those providers who use voice or video data to infer the personality and skills of applicants.
- To counteract this, Unilever points out that video interviews are optional. In addition, applicants are asked to consent or decline to automated decision-making in the evaluation of their video interview. They are also given information on how to prepare and could choose to speak to a talent advisor as an alternative if they wish [53].
- It is also critical that the use of artificial intelligence can only be as good as the programming. This also means that wrong decisions can be made. For example, when analysing body language, even a quick body movement can be misinterpreted as a sign of insecurity and lead to a malus or exclusion of the person, while

the person actually only used his or her hands to illustrate a process, which would actually even be positive. This means that HR managers cannot rely exclusively on artificial intelligence and should take their own critical look at the results and how they came about, which in turn ties up time and human resources [56, 58].

Chatbots

- Speech-based chatbots can reach their limits when ambient noise is too loud, strong dialect or complicated wording and concerns are spread across multiple messages [67].
- Speech-based chatbots only work through pre-structured question-and-answer schemes, so they can only act as their rules and the information database they draw on allow. This limits the possible questions that the chatbot can answer, as well as the answers. These can vary in wording, but otherwise always turn out the same, no matter what situation (emotional mood) the human interaction partner is in [67].
- Currently (2019), only 2.8% of the top 1000 companies offer chatbots in recruiting, even though many assume that chatbots will be used more and more in the future—if only because younger candidates in particular would like to use such systems [43].
- If companies use several different channels to address applicants, it must be ensured that the information from these many different channels flows into each other (multichannel capability), ideally in such a way that the respective system knows the discussion status from the other channels, because otherwise the user would have to enter all the information again.
- Chatbots are online 24 h a day and respond immediately—as long as they are trained to understand the questions and have suitable answers stored, such as questions about salary or job requirements. Questions that the chatbot cannot (yet) answer are forwarded to a human recruiter and the answers are saved for the future [68].
- With regard to the acceptance of such systems, it is a recurring theme that bots would not be capable of empathetic, empathic communication and thus would not be able to express appreciation [43].

Online assessments

- Games or playful elements are increasingly used in both self-selection and selection by others. However, these terms should not hide the fact that the games are also tests. Therefore, the instruments used should also fulfil the requirements formulated for occupation-related aptitude diagnostics, such as those stated in DIN 33430, i.e. in addition to objectivity, reliability and validity, they should also have a theoretical foundation and a reference to the requirements and be appropriate [49].
- While games or tests are widely accepted in Germany and worldwide [49], speech and video analyses have only been around for a few years—and they have come in for criticism, especially in Germany [49].

- In addition to the question of which target groups such games are suitable for (e.g. apprentice versus manager), the main question is to what extent the games cover the real requirements of the job. In addition, the game behaviour is used to infer selection-relevant personal characteristics, which is to be criticised from an aptitude-diagnostic point of view.
- Online assessments can be completed around the clock from anywhere in the world, provided there is an internet connection. The evaluation is automated, which is economically advantageous for the employer. Once the systems [69] have been developed, follow-up costs and time are rather low.
- They 'fit' into the digital age, as young target groups in particular want to be reached and companies want to give themselves the image of a "modern" employer [70].
- The systems must meet high usability requirements, as they must function in the same way on all devices and browsers in order to generate objective and reliable results (e.g. smartphone display versus 27″ monitor). The structure and design of such assessments are therefore associated with a high level of effort [33].
- Since the tests are usually always the same, they can be trained—or the candidates get support, which falsifies the test results.
- In addition, online assessments reduce the personal contact between applicants and recruiters.

Automated cancellations

- It is important to consider what signal is fundamentally sent with such an automated rejection. This is especially true in tight labour markets, where it is likely that all parties involved will want (or need) to meet and work together again later [43].
- In addition, standardised rejections are not smart if they are not data-based and do not address the individual case [33].

5 Conclusion

In summary, the picture is rather ambivalent. First of all, it can be mentioned that there are numerous opportunities that Smart Human Resource Management offers when designed and applied appropriately. These include, in particular, the fact that large amounts of data can be used in a targeted manner. This already applies to finding and approaching suitable candidates to fill vacancies, which plays a decisive role especially against the background of the 'war for talents' in order to be able to successfully counteract the shortage of skilled workers in many labour markets—and this applies especially to small and medium-sized enterprises, some of which are little known but make up the majority of the economy. In addition, employer branding can be improved in the same way as social media presence. The possibility of a low-threshold and uncomplicated first approach and information from chatbots is also explicitly addressed here. These aspects are especially significant for applicants

of generations Y and Z and future alpha—it meets the typical demands and usage behaviour of people entering the labour market. In addition, numerous improvements can also be achieved internally. Algorithms can be used to link data in an appropriate way and thus provide a sound basis for making decisions.

However, the numerous advantages are also contrasted by many requirements and challenges. In particular, the technologies can also be used in a critical and unprofessional way. This applies especially to the human factor and its competences. If these are not available or only inadequately available, there is a risk of wrong decisions and the resulting undesirable developments. Well-founded expertise in several areas is required in order to use the possibilities of artificial intelligence in an appropriate form, and the introduction also requires time, personnel and financial resources that should not be underestimated, depending on the desired application. In addition, there are also open legal questions, for example related to the use of personal data in cross-border traffic and the danger of cybercrime. In the area of Personnel Marketing and Recruiting, it is about automated searching, matching and suggesting, e.g. new jobs, team colleagues, learning content or procedures.

Digitalisation now offers opportunities to break completely new ground through data-driven recruiting and process automation. And 'most recruiters not only expect a fundamental change in recruitment as a result of this, but are even unusually open to these changes', as Laumer's 2019 study shows, not least in order to be ahead of the competition. The daily work will be changed by digitalisation, whereby effectiveness and efficiency advantages can be realised. Digitisation offers potential advantages for both sides, the searching company and the searching candidate.

In order to ensure effective and efficient use of these systems and to be able to learn in the long term, the fundamental challenge for companies is to ensure transparency about their processes and activities in human resources management and the quality of the data required in each case. The most important thing here is to build up machine-readable data in sufficient quantity to be able to develop, train and apply the systems described and the underlying algorithms. However, this requires a systematic, well thought-out and technically competent handling of the technologically given possibilities—including appropriate communication among humans, but also between humans and machines. The human factor—as before influences the quality of the design.

References

1. Oracle: From fear to enthusiasm: artificial intelligence is winning more hearts and minds in the workplace (2019). https://www.oracle.com/a/ocom/docs/applications/hcm/ai-at-work-ebook.pdf. Accessed 24 Feb 2022
2. Ancarani, A., Di Mauro, C., Mascali, F.: Backshoring strategy and the adoption of Industry 4.0: evidence from Europe. J. World Bus. **54**, 360–371 (2019). https://doi.org/10.1016/j.jwb.2019.04.003

3. Marler, J.H., Parry, E.: Human resource management, strategic involvement and e-HRM technology. Int. J. Hum. Res. Manage. **27**, 2233–2253 (2016). https://doi.org/10.1080/09585192.2015.1091980
4. Larivière, B., Bowen, D., Andreassen, T.W., et al.: "Service encounter 2.0": an investigation into the roles of technology, employees and customers. J. Bus. Res. **79**, 238–246 (2017). https://doi.org/10.1016/j.jbusres.2017.03.008
5. Malik, A., Budhwar, P., Patel, C., et al.: May the bots be with you! Delivering HR cost-effectiveness and individualised employee experiences in an MNE. Int. J. Hum. Res. Manage. 1–31 (2020). https://doi.org/10.1080/09585192.2020.1859582
6. Cooke, F.L., Liu, M., Liu, L.A., et al.: Human resource management and industrial relations in multinational corporations in and from China: challenges and new insights. Hum. Resour. Manage. **58**, 455–471 (2019). https://doi.org/10.1002/hrm.21986
7. Bondarouk, T., Harms, R., Lepak, D.: Does e-HRM lead to better HRM service? Int. J. Hum. Res. Manage. **28**, 1332–1362 (2017). https://doi.org/10.1080/09585192.2015.1118139
8. Abraham, M., Niessen, C., Schnabel, C., et al.: Electronic monitoring at work: the role of attitudes, functions, and perceived control for the acceptance of tracking technologies. Hum. Resour. Manag. J. **29**, 657–675 (2019). https://doi.org/10.1111/1748-8583.12250
9. Colbert, A., Yee, N., George, G.: The digital workforce and the workplace of the future. Acad. Manag. J. **59**, 731–739 (2016). https://doi.org/10.5465/amj.2016.4003
10. Thomaz, F., Salge, C., Karahanna, E., et al.: Learning from the Dark Web: leveraging conversational agents in the era of hyper-privacy to enhance marketing. J. Acad. Mark. Sci. **48**, 43–63 (2020). https://doi.org/10.1007/s11747-019-00704-3
11. Bondarouk, T., Parry, E., Furtmueller, E.: Electronic HRM: four decades of research on adoption and consequences. Int. J. Hum. Res. Manage. **28**, 98–131 (2017). https://doi.org/10.1080/09585192.2016.1245672
12. Parry, E., Tyson, S.: An analysis of the use and success of online recruitment methods in the UK. Hum. Resour. Manag. J. **18**, 257–274 (2008). https://doi.org/10.1111/j.1748-8583.2008.00070.x
13. Schaubroeck, J.M., Yu, A.: When does virtuality help or hinder teams? Core team characteristics as contingency factors. Hum. Resour. Manag. Rev. **27**, 635–647 (2017). https://doi.org/10.1016/j.hrmr.2016.12.009
14. Hoch, J.E., Dulebohn, J.H.: Team personality composition, emergent leadership and shared leadership in virtual teams: a theoretical framework. Hum. Resour. Manag. Rev. **27**, 678–693 (2017). https://doi.org/10.1016/j.hrmr.2016.12.012
15. Bondarouk, T., Brewster, C.: Conceptualising the future of HRM and technology research. Int. J. Hum. Res. Manage. **27**, 2652–2671 (2016). https://doi.org/10.1080/09585192.2016.1232296
16. Park, R.: The roles of OCB and automation in the relationship between job autonomy and organizational performance: a moderated mediation model. Int. J. Hum. Res. Manage. **29**, 1139–1156 (2018). https://doi.org/10.1080/09585192.2016.1180315
17. Buckley, P., Minette, K., Joy, D., et al.: The use of an automated employment recruiting and screening system for temporary professional employees: a case study. Hum. Resour. Manage. **43**, 233–241 (2004). https://doi.org/10.1002/hrm.20017
18. Seeck, H., Diehl, M.-R.: A literature review on HRM and innovation—taking stock and future directions. Int. J. Hum. Res. Manage. **28**, 913–944 (2017). https://doi.org/10.1080/09585192.2016.1143862
19. Bhardwaj, G., Singh, S.V., Kumar, V.: An empirical study of artificial intelligence and its impact on human resource functions. In: Abstract Proceedings of International Conference on Computation, Automation and Knowledge Management (ICCAKM-2020), 9th–10th January 2020. IEEE, Piscataway, NJ, pp. 47–51 (2020)
20. Leicht-Deobald, U., Busch, T., Schank, C., et al.: The challenges of algorithm-based HR decision-making for personal integrity. J. Bus. Ethics **160**, 377–392 (2019). https://doi.org/10.1007/s10551-019-04204-w

21. O'Neil, C.: Weapons of math destruction: How big data increases inequality and threatens democracy, 1st edn. Crown, New York (2016)
22. Feenberg, A.: The ambivalence of technology. Sociol. Perspect. **33**, 35–50 (1990). https://doi.org/10.2307/1388976
23. Backhaus, N.: Kontextsensitive Assistenzsysteme und Überwachung am Arbeitsplatz: Ein meta-analytisches Review zur Auswirkung elektronischer Überwachung auf Beschäftigte. Z Arb Wiss **73**, 2–22 (2019). https://doi.org/10.1007/s41449-018-00140-z
24. Jia, Q., Guo, Y., Li, R., et al.: A conceptual artificial intelligence application framework in human resource management. In: International Conference on Electronic Business (ICEB) 2018 Proceedings, pp. 106–114
25. Tambe, P., Cappelli, P., Yakubovich, V.: Artificial intelligence in human resources management: challenges and a path forward. Calif. Manage. Rev. **61**, 15–42 (2019). https://doi.org/10.1177/0008125619867910
26. Strohmeier, S., Piazza, F.: Artificial intelligence techniques in human resource management—a conceptual exploration. In: Kahraman, C., Çevik Onar, S. (eds.) Intelligent Techniques in Engineering Management: Theory and Applications, vol. 87. Springer International Publishing, Cham, s.l., pp. 149–172 (2015)
27. Berhil, S., Benlahmar, H., Labani, N.: A review paper on artificial intelligence at the service of human resources management. Indonesian J. Electr. Eng. Comput. Sci. **18**, 32–40 (2020). https://doi.org/10.11591/ijeecs.v18.i1.pp32-40
28. Gärtner, C.: Grundlagen: KI, ML, DL, RPA und Co. In: Gärtner, C. (ed.) Smart HRM: Digitale Tools für die Personalarbeit. Springer Gabler, Wiesbaden, Heidelberg, pp. 17–50 (2020)
29. Zhang, X., Zhou, Y., Ma, Y., et al.: GLMix: generalized linear mixed models for large-scale response prediction. In: Krishnapuram, B. (ed.) Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining. ACM, New York, NY, pp. 363–372 (2016)
30. Scholz, C., Scholz, T.M.: Grundzüge des Personalmanagements, 3. Auflage. Verlag Franz Vahlen, München (2019)
31. Abel, J., Klohs, K., Lehmann, H., et al.: Sentiment-analysis for German employer reviews. In: Abramowicz, W. (ed.) Business Information Systems Workshops: BIS 2017 International Workshops, Poznań, Poland, June 28–30, 2017, Revised Papers, vol. 303. Springer International Publishing AG, Cham, pp. 37–48 (2017)
32. Liu, B., Fersini, E., Messina, E., et al. (eds.): Sentiment Analysis in Social Networks. Morgan Kaufmann, Cambridge, MA (2017)
33. Gärtner, C. (ed.): Smart HRM: Digitale Tools für die Personalarbeit. Springer Gabler, Wiesbaden, Heidelberg (2020)
34. Gelbard, R., Ramon-Gonen, R., Carmeli, A., et al.: Sentiment analysis in organizational work: towards an ontology of people analytics. Expert. Syst. **35**, e12289 (2018). https://doi.org/10.1111/exsy.12289
35. Gloor, P.A., Fronzetti Colladon, A., Grippa, F., et al.: Forecasting managerial turnover through e-mail based social network analysis. Comput. Hum. Behav. **71**, 343–352 (2017). https://doi.org/10.1016/j.chb.2017.02.017
36. Shi, Y., Zhu, L., Li, W., et al.: Survey on classic and latest textual sentiment analysis articles and techniques. Int. J. Inf. Technol. Decis. Mak. **18**, 1243–1287 (2019). https://doi.org/10.1142/S0219622019300015
37. Moniz, A., de Jong, F.: Sentiment analysis and the impact of employee satisfaction on firm earnings. In: de Rijke. M., Kenter, T., de Vries, A.P., et al. (eds.) Advances in Information Retrieval: 36th European Conference on IR Research, ECIR 2014, Amsterdam, The Netherlands, April 13–16, 2014; Proceedings, vol. 8416. Springer, Cham, pp. 519–527 (2014)
38. Stone, P., Chatagny, J.: Analytics als Wandelmotor nutzen: ein Erfahrungsbericht zur Neugestaltung interner Dienste bei der Swiss Re. Organisationsentwicklung: Zeitschrift für Unternehmensentwicklung und Change Management **38**, 6–12 (2019)
39. Lochner, K., Preuß, A.: Digitales Recruiting. Gruppe. Interaktion. Organisation. Zeitschrift für Angewandte Organisationspsychologie (GIO) **49**, 193–202 (2018). https://doi.org/10.1007/s11612-018-0425-7

40. Textmetrics: Augmented writing platform | Textmetrics (2021). https://www.textmetrics.com/diversity-and-inclusion/augmented-writing?page_id=73911. Accessed 24 Feb 2022
41. Holm, A.B.: E-recruitment: towards an ubiquitous recruitment process and candidate relationship management. Ger. J. Hum. Res. Manage. **26**, 241–259 (2012). https://doi.org/10.1177/239700221202600303
42. Alkhazraji, I., Buhaliba, A.: Using machine learning software in the human resource recruiting process for candidates from Dubai Police Academy. Thesis, Rochester Institute of Technology (2020)
43. Laumer, S., Weitzel, T., Luzar, K.: Robo-recruiting: status quo und Herausforderungen für die KI in der Personalgewinnung. Personal Quarterly: Wissenschaftsjournal für die Personalpraxis 10–15 (2019)
44. Sidoruk, J., Ritter, H.: Künstliche Intelligenz – Kriegstreiber oder Friedensstifter im War for Talent? In: Altenburger, R., Schmidpeter, R. (eds.) CSR und Künstliche Intelligenz. Springer Gabler, Berlin, Heidelberg, pp. 327–340 (2021)
45. Nawaz, N., Gomes, A.M.: Artificial intelligence chatbots are new recruiters (2019)
46. Portugal, I., Alencar, P., Cowan, D.: The use of machine learning algorithms in recommender systems: a systematic review. Expert Syst. Appl. **97**, 205–227 (2018). https://doi.org/10.1016/j.eswa.2017.12.020
47. Nawaz, N.: How far have we come with the study of artificial intelligence for recruitment process. Int. J. Sci. Technol. Res. (2019)
48. Garg, S., Sinha, S., Kar, A.K., et al.: A review of machine learning applications in human resource management. Int. J. Product. Perform. Manag. (2021). https://doi.org/10.1108/IJPPM-08-2020-0427
49. Diercks, J.: Online-assessment. In: Verhoeven, T. (ed.) Digitalisierung Im Recruiting: Wie Sich Recruiting Durch Künstliche Intelligenz, Algorithmen und Bots Verändert, pp. 79–99. Springer Fachmedien Wiesbaden GmbH, Wiesbaden (2020)
50. Javed, A., Brishti, J.K.: The Viability of AI-Based Recruitment Process: A Systematic Literature Review. Umea University (2020)
51. Tschöpe, N., Basch, J., Diaz, P., et al.: Asynchronous Video Interviews today—Artificial Intelligence Analysis tomorrow? (2021)
52. Saini, H., Tarkar, P.: Artificial intelligence in human resource practices with challenges and future directions. In: Wang, J., Garg, V., Goel, R. (eds.) Handbook of Research on Innovative Management Using AI in Industry 5.0. IGI Global, pp. 222–230 (2022)
53. Booth, R.: Unilever saves on recruiters by using AI to assess job interviews. The Guardian (2019)
54. Peeters, T., Paauwe, J., van de Voorde, K.: People analytics effectiveness: developing a framework. J. Organ. Effectiveness People Performance **7**, 203–219 (2020). https://doi.org/10.1108/JOEPP-04-2020-0071
55. Zuiderveen, B.F.: Discrimination, artificial intelligence, and algorithmic decision-making (2018)
56. Köchling, A., Wehner, M.C.: Discriminated by an algorithm: a systematic review of discrimination and fairness by algorithmic decision-making in the context of HR recruitment and HR development. Bus. Res. **13**, 795–848 (2020). https://doi.org/10.1007/s40685-020-00134-w
57. Blum, B., Kainer, F.: Rechtliche Aspekte beim Einsatz von KI in HR: Wenn Algorithmen entscheiden. Personal quarterly: Wissenschaftsjournal für die Personalpraxis, 22–27 (2019)
58. Zhang, X., Zhang, S., Liu, J., et al.: Artificial intelligence recruitment analysis. In: Liu, Y., Wang, L., Zhao, L., et al. (eds.) Advances in Natural Computation, Fuzzy Systems and Knowledge Discovery, vol. 1075, pp. 434–442. Springer International Publishing, Cham (2020)
59. Tishby, N., Zaslavsky, N.: Deep learning and the information bottleneck principle. In: 2015 IEEE Information Theory Workshop (ITW 2015): Jerusalem, Israel, 26 April–1 May 2015. IEEE, Piscataway, NJ, pp. 1–5 (2015)
60. Ntoutsi, E., Fafalios, P., Gadiraju, U., et al.: Bias in data-driven artificial intelligence systems—an introductory survey. WIREs Data Min. Knowl. Discov. **10**, e1356 (2020). https://doi.org/10.1002/widm.1356

61. Nelson, G.S.: Bias in artificial intelligence. N C Med. J. **80**, 220–222 (2019). https://doi.org/10.18043/ncm.80.4.220
62. Rambachan, A., Roth, J.: Bias in, bias out? Evaluating the folk wisdom. Schloss Dagstuhl - Leibniz-Zentrum für Informatik (2020)
63. Oviatt, S., Schuller, B., Cohen, P.R., et al. (eds.): The Handbook of Multimodal-Multisensor Interfaces, 1st edn. ACM books, #23. ACM; M&C, New York, NY, Williston, VT (2019)
64. Castelvecchi, D.: Can we open the black box of AI? Nature **538**, 20–23 (2016). https://doi.org/10.1038/538020a
65. Lambrecht, A., Tucker, C.: Algorithmic bias? An empirical study of apparent gender-based discrimination in the display of STEM career ads. Manage. Sci. **65**, 2966–2981 (2019). https://doi.org/10.1287/mnsc.2018.3093
66. Liu, B.: Sentiment Analysis: Mining Opinions, Sentiments, and Emotions. Studies in Natural Language Processing. Cambridge University Press (2020)
67. Stucki, T., D'Onofrio, S., Portmann, E.: Chatbot – Der digitale Helfer im Unternehmen: Praxisbeispiele der Schweizerischen Post. HMD **55**, 725–747 (2018). https://doi.org/10.1365/s40702-018-0424-8
68. Ott, A.: A year with our recruiting chatbot (2017). https://medium.com/@frauott/a-year-with-our-recruiting-chatbot-e77f52264a
69. Poniszewska-Maranda, Kaczmarek, D., Kryvinska, N., Xhafa, F.: Studying usability of AI in the IoT systems/paradigm through embedding NN techniques into mobile smart service system. Computing **101**(11), 1661–1685 (2019). https://doi.org/10.1007/s00607-018-0680-z
70. Geister, S., Rastetter, D.: Aktueller Stand zum Thema Online-Tests. In: Steiner, H. (ed.) Online-Assessment: Grundlagen und Anwendung von Online-Tests in der Unternehmenspraxis, pp. 3–16. Springer Berlin Heidelberg, Berlin, Heidelberg (2009)

The Impact IT Sector in the Structure of the Economy

Zuzana Stoličná and Lucia Klapáčová

Abstract The paper is focused on one of the fastest growing industries in the world. The IT sector is very important part of every economy. It deals in more detail with the characteristics and analysis of the development and changes of the IT sector in the structure of the economy. The aim of this paper is to characterize the position of the IT sector in the structure of the Slovak economy. It attempts to analyze the position of the IT sector in the past, and also addresses current trends. The results of the analysis confirmed the important position of the IT sector in selected Nordic economies and only partially in the Slovak economy.

1 Introduction

The IT sector is currently one of the fastest growing industries in the world. The sector is known for both high risks and the possibility of a large return on investment. In addition to the fact that information technology can make businesses more cost-effective and productive, the development of IT products and services can generate more revenue.

Information technology affects people's daily lives in many ways, not only at work but also at home. The IT sector is currently developing at a very fast pace and is increasingly intervening in every area, every industry, sector and therefore it is very beneficial for the economies of the states and for this reason it is important to address this issue.

The IT sector intervenes in industry, commerce, agriculture, healthcare, education, and even the police and the military. We can find it in every single industry. The introduction of IT technologies causes automation of production, efficient use

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of resources, effective communication with employees or with clients, customers. It allows you to handle the necessary matters without the need for a personal visit to the branch, but quickly and efficiently via the Internet and IT equipment electronically. Businesses use a variety of information systems, advertising websites, various software applications, such as various economic software, accounting software, payroll software, supply software, and more.

The aim of this paper is to characterize the position of the IT sector in the structure of the Slovak economy. Analyze the impact of the IT sector on the economy of the Slovak Republic, its changes and benefits. Furthermore, to characterizethe individual components, industries in which the IT sector intervenes.

The paper is focused on a specific analysis of the IT sector. It describes basic data on the IT sector such as the development of the numero fof enterprises in IT sector od the share of IT sector in the economy. The last part of paper contains the conclusions for the economy of the Slovak Republic.

2 Conceptual Background

Within this chapter we characterize information technologies, IT sector but also individual components of IT sector. We will do so through the statistical classification SK NACE, where subsequently the basis of individual parts of the IT sector are the basis for the analysis of the IT sector in the structure of the Slovak economy. Also in this chapter we will mention the benefits that come with the use, seduction and expansion of the IT sector.

2.1 Characteristics of the IT Sector

Information technology (IT) has introduced the information age and set in motion a digital revolution that should enable the creation of a knowledge society built and maintained in a technologically advanced global economy. Commonly used synonyms for information technology include computers, computer networks, software, hardware, web design, electronics, telecommunications, and semiconductors [8]. We classify information technology among the business sectors that deal with computer technology, including hardware, software, telecommunications, and everything that is involved in the transmission of information or systems that facilitate communication. IT also includes data management, whether in the form of text, voice, image, sound or otherwise. It can also include things related to the Internet. IT has become part of our daily lives and continues to expand into new realms [9].

The IT sector is mainly engaged in IT-related services. The IT sector plays an important role in the country's development, providing products and services that support the effective functioning of today's global information society and that are an integral part of operations and services provided by other sectors. It consists of

small and medium-sized as well as large multinational companies. Unlike many critical infrastructure sectors based on limited and easily identifiable physical assets, the IT sector is a feature-based sector that includes not only physical assets but also virtual systems and networks that enable key capabilities and services in both the public and private sectors [5]. The IT sector's functions include a set of processes involved in the creation of IT products and services, including research and development, manufacturing, distribution, upgrades and maintenance. They also support the sector's ability to produce and deliver highly secure products, services and processes that are resilient to threats and can be recovered quickly. Features are not limited by geographical or political boundaries, which further defines its virtual and distributed nature [5].

2.2 Benefits of the IT Sector

The strategic importance of the IT sector is widely recognized in both developed and developing and emerging countries. Many governments have recognized the key role of this extremely dynamic sector, which enables income generation and employment promotion. The IT sector has significant export potential and contributes significantly to improving productivity, efficiency and innovation in both the public and private sectors [4].

In terms of economic development, the IT sector can primarily contribute to:

- Economic growth: The IT sector creates significant potential for generating economic growth, which creates job creation, reduced unemployment and income generation. The IT sector is increasingly contributing to the country's GDP.
- Increase investment: Developing and developing countries with a strong IT industry usually achieve better results in attracting foreign direct investment than economically developed countries. This is not only due to the growing trend towards outsourcing, but also due to that the support of the IT industry helps to increase the country's attractiveness by improving its technical environment and its skills.
- Job creation: The positive influx of the IT sector into job creation is exacerbated by the fact that IT is a skilled labor-intensive industry. The VIT sector needs a number of skilled employees such as programmers, developers, software engineers, IT consultants, IT analysts and many others. In terms of employment, it has two positive effects on the development of the IT sector - quantitative job growth and qualitative job creation for higher-skilled people.
- Competitiveness: An important economic benefit of the IT sector is its positive impact on the efficiency and productivity of other industries through externalities. In this way, even traditional industries such as manufacturing or agriculture can improve their international competitiveness by using modern IT applications. By adopting the latest technologies and providing modern software applications,

industries are able to integrate into international markets. In addition, the IT sector can trigger growth effects in related industries through multiplier effects.

Innovation: As a cross-cutting technology, IT is the driving force behind product innovation and processes. Therefore, the IT sector plays a crucial role in increasing investment capacity in countries, especially in terms of open innovation [4].

2.3 Sectoral Structure of the Economy

The sector can be characterized as a descent of institutional units that have similar characteristics and economic behavior. Sectors are created by grouping industries. The individual sectors depend on the nature of the activity, the level of scientific and technical progress and labor productivity [7].

Within the sectoral division, we distinguish 5 types of sectors:

- Primary sector—represents the basic sector of the national economy. They belong here to primary production enterprises (agricultural, forestry, mining, energy enterprises and fisheries), the common feature of which is the acquisition of natural goods in the form of raw materials.
- Secondary sector—builds on the primary sector, produces new products and values. The here companies of manufacturing and construction.
- Tertiary sector—consists of companies providing services to the population but also some production activities. These include, for example, trade, banking, transport, communications, repair services and the like.
- Quaternary sector—services of a public nature providing the legislative and legal framework for the functioning of the state. Their goal is not to make a profit, so the state participates in their development. These include, for example, the public administration, the army, the judiciary and the police.
- The fifth sector of the development services sector, which dynamizes economic growth with a focus on its quality side. These include services that have the task of preserving and cultivating human potential, i.e. services provided by education, culture, health, social services, physical culture and sport, other science services and institutions that create and distribute information [7].

Today, the IT sector is part of every single industry. Within the sectoral structure of the Slovak economy, the IT sector intervenes in all five sectors. The IT sector can be found in industry, construction, trade, banking, healthcare, education, culture and sports, and even in the army, police and other sectors of the Slovak Republic. But as such, we primarily classify it in the Quartet sector.

2.4 Classification of the IT Sector in the Structure of the Slovak Economy According to SK NACE Rev.2

As part of the bachelor's thesis, we will classify the IT sector in the structure of the Slovak economy through the Statistical Classification SK NACE Revision 2. Some IT manufacturing needs to go through a manufacturing, assembly, or transformation process, consequently, these devices are also needed and there are trains and companies that do not only produce, distribute or provide IT and consequently need to think about repairing and maintaining theseinformation technology. It is for this reason that the IT sector is classified into several sections within the Statistical Classification of Economic Activities SK NACE.

From the perspective of the approach that defines Information Technology as the business sectors that deal with computing, including hardware, software, telecommunications, and everything involved in the transmission of information or systems that facilitate communication. IT also includes data management, whether in the form of text, voice, image, sound or otherwise. It can also include things related to the Internet. IT has become a part of our daily lives and continues to expand into new realms [9].

Within the statistical classification SK NACE we can classify the IT sector in the following sections (Fig. 1):

- C—Industrial production
- J—Information and communication
- S—Other activities

Section C—Industrial is production, focused on production, assembly, transformation of materials into new products. In the case of the IT sector, it is the production, assembly, transformation of materials into new products in the field of information

Section C - Industrial production	
Division	**Group**
26	Manufacture of computer electronic and optical products
Section J - Information and communication	
Division	**Group**
59	Production of video films, television programs, preparation and publication of sound recordings
60	Radio and television broadcasting activities
61	Telecommunications
62	Computer programming consultancy and related services
63	Information Services
Section S - Other activities	
Division	**Group**
95	Repair of personal computer and household goods

Fig. 1 Statistical classification SK NACE [21]

technology. Such as the manufacture of computers, peripherals, electronic components, the manufacture of communications equipment (eg telephones) and many other IT equipment and devices [15].

Section J—Information and communication is considered to be a major part of the IT sector. All companies that provide IT products or services are listed in this section. The Information and Communication section can be defined as an IT sector in which all companies engaged in the production and distribution of information and cultural products, the provision of means for the transmission or distribution of these products as well as data and communication products are included, includes as well as information technology, data processing and other information service activities. This section is further divided into 6 divisions [15].

Section S—Other services can be defined as a section that includes repairs of computers and goods for personal use as well as for household. It includes, for example, the repair of personal computers, laptops, mobile phones and other IT devices [15].

3 Methodology

The main goal of the paper was to analyze the position of the IT sector in the structure of the Slovak economy. Achieving the main goal was made possible by three sub-goals, which we set ourselves at the beginning.

Among the partial goals of the work we have included:

- Characterize the IT sector and its components,
- Analyze the position of the IT sector in the structure of the Slovak economy,
- Evaluate the achieved results.

We tried to answer questions about whether the IT sector also affects other industries or we can consider it only as a separate industry. We focused on he analysis of the number of IT sectors we can classify as key industries. The reason for this analysis is that the development of technology is very fast, dynamic, affects all industries, areas, sectors in countries around the world. Our assumption is that the industry is one of the key sectors in the economy of the Slovak Republic. This results in a research question: In which monitored years did the IT sectors belong to the key sectors of the Slovak Republic? In the next step, we analyzed the position of the IT sector in the structure of the Slovak economy based on its impact on economic growth in our country. Whether we can consider the IT sector the most important in creating GDP monthly wage in this sector and on many other indicators within the Slovak Republic.

We relied on sources from Slovak and foreign literature, although a substantial part of the theoretical part we drew from data from Eurostat or the Statistical Office, because they provided enough information to characterize the IT sector and identify its components, through the Statistical Classification of Economic activities of SK NACE Revision 2. In the theoretical part we answered the first research question: Is

the IT sector intervening in other industries or do we consider it only as a separate industry?

To achieve the goals, we used the Eurostat database, which can be characterized as the Statistical Office of the European Union, the database of the Statistical Office in the Slovak Republic. Through Eurostat and the Statistical Office of the Slovak Republic, we determined the number of employees working in the IT sector, the share of the IT sector in the GDP of the Slovak Republic.

3.1 Current State and Position of the IT Sector

The world has changed significantly in recent decades. Changes can be seen in globalization, informatization or new discoveries in science and technology. Today, we encounter information technology at virtually every step. Today's young generation meets them almost immediately when they begin to function as a social individual. The moment he picks up a mobile phone, sends the first e-mail or creates an account on a social network, he enters the world of information technology. If we can call, send an SMS or browse a website via a mobile phone, for example, it is nothing more than IT used in practice. The huge phenomenon that we can consider IT is against the background of all social networks, e-mails, modern films and fairy tales, CT or NMR in medicine, space programs, rockets or satellites. As new descriptions, features or areas of application continue to be added to the IT definition, it is increasingly difficult to establish a generally established definition [6].

If we look at IT from a basic technical point of view, IT as a department covers the areas of design, creation, storage, exchange and processing of some digital information. It is often said that IT is the basis of the modern digital economy. The digital economy refers to the ability of information technology to bring together people, businesses and various organized groups of people and tools around the world. The more a country or company is able to use IT, the higher its productivity, outperform the competition, enter new markets and reach new customers. As information technologies present new opportunities for businesses and people, they are forced by the market mechanism to innovate faster and faster.

The IT industry is constantly evolving, changing and growing. Technologies such as 3D printing, high-speed mobile internet, cloud computing, intelligent global gaming systems and virtual reality are currently entering the world. All these new technologies require people. IT is a tool that automates processes, but there is still a need for a worker to invent this technology, further design and model it. Later, a person is needed to program, test, repair or supplement it for the needs and ideas of the customer. When it comes to using specific technology, it is necessary to have a person who will ensure the migration of data from the old solution to the new and many other important steps. There are a wide range of career opportunities in the IT industry, which are among the most lucrative in terms of challenges but also potential rewards [6].

The IT sector is an industry characterized by dynamic change, shortening production cycles and rapid innovation. Every year, information and communication technologies provide new application possibilities in enterprise information infrastructures [20].

According to the business organization Swedish IT and Telecom Industries (IT & Telekomföretagen) we can ICT business can be divided into four main segments [3]:

- hardware production
- hardware sales services
- telecommunication and data communication services
- software products and IT services

We understand the company's computerization as a managed process that aims to make the most of the potential that the IT industry offers. The most important benefits of informatization include: increased quality of life of users, creation of conditions for building a knowledge economy using means and methods of informatics and streamlining of business processes. We can use as examples the reduction of business transaction costs, new business opportunities in global markets for small and medium enterprises. We will also include the creation of new jobs for skilled workers and increasing the share of high value-added production. The rationalization of production processes, the saving of raw materials and energy, regional development through the wide dissemination of information and new forms of work help to increase competitiveness and employment [3].

While ICTs continue to be an effective source of reducing existing costs, they are also increasingly seen as a tool introduced by innovation and revenue growth, as they enable new services and ways of working within value chains and networks. Emerging trends include:

- ICT for sustainable industrial development,
- Impacts of e-commerce on business models,
- ICT and innovation are becoming inseparable.

In the ICT sector, EU policy places particular emphasis on the importance of the skills needed in this area. However, companies face persistent problems as they try to find these skills among employees. Key aspects to be addressed include: training ICT professionals, providing adequate information on ICT and e-commerce to management to enable strategic planning and, where necessary, developing sector-specific approaches [16].

The ICT sector includes ICT services and ICT production in general. ICT production contributes around 1% of GDP and the ICT services sector is responsible for just under 4% of GDP. The use of ICT can help make any economy more competitive. ICT is a key driver in putting innovation into practice. Improving ICT and related innovation activities are ongoing processes that combine business processes, organizational structures, competencies and responsibilities, human resources, personal skills, knowledge, hardware, software and other components of the organization.

These components are only elements of the system, the new qualitative and innovative potential brings with it a reassessment of the whole system using appropriate

ICT principles. One of the main challenges for ICT take-up in global society and business is due to a lack of adequately knowledgeable ICT professionals [14].

3.2 Development of the IT Sector

In order to understand the processes and impacts of the IT industry, it is necessary to take into account historical developments. In the modern context, the term IT is commonly used to refer to computers and networks in a business environment. It covers their application in the generation, manipulation, storage, retrieval, transmission, exchange, study and security of all data or information in electronic format. The term IT is also used as a umbrella term for television, telecommunications equipment, software, e-commerce and the Internet.

People have manipulated, stored and communicated information since the early Sumerians pioneered the written word in ancient Mesopotamia around 3000 BC. The technology industry is relatively young. Its origins can be traced back to the invention of the two-element electron tube of 1904. This was followed by developments such as the transitor, integrated circuit in the 1950s and analog devices 3 in 1960. Many of these inventions were the result of military research. The 1970s brought the invention of the integrated circuit board and microprocessors that soon followed. Microprocessors have enabled the use of home and personal computers. However, until the Internet was not available to ordinary consumers, computers were not very popular. In the 1990s, when the Internet was available to all, there was an expansion in the use of personal computers. Computers gradually entered the everyday lives of ordinary people and were no longer a phenomenon as in the beginning. This is one of the reasons why the demand for computers dropped dramatically in 2000. One of the world's largest computer manufacturers, Apple Computer Inc., also saw a drop in revenue during this period, citing lower sales in all geographies as well as unplanned promotions and lower product prices [9].

The market saw a turnaround in 2003 and 2004 as customers searched for multipurpose computers that could handle a myriad of photo, video and audio applications. Since then, the technology has spread to mobile phones and tablets, which provide all the services of a regular stationary computer. Cloud computing has revolutionized data storage, and as a result, devices are constantly shrinking and improving [10].

The information technology industry is booming and more and more companies and brands are trying to do this areas expand with a huge potential. Information technologies create various applications, that is why they have proven to be such a useful key component in the whole structure.

With the growing importance of the IT industry, it is important to understand its important aspects that make it a revolutionary tool. One of the biggest trends that has emerged in the last year is the development of cloud computing. Coraz more industries are aware that it is important for a company to have a designated place for all its digital information and resources, and also to have a well-protected place to ensure their security. Cloud computing is a solution for companies that want to

improve their work and make it more efficient in the digital space. The popularity of mobile applications has expanded over the last few years. Industries around the world are trying to find ways to improve their work with mobile applications that can make their work more efficient. Big data analysis is a trend that has grown in recent years and is now being implemented in almost every type of industry that uses extensive manufacturing processes. Big data analysis allows companies to better process their information, and also helps them better understand the areas they need to develop. Automation is one of the trends that has hit production units hard and is expected to grow only more in the coming years. Another common factor that comes to the fore is artificial intelligence. Intelligent machines that use intelligence or automation are on the rise. The gaming industry is also one that is experiencing growth as it provides customers with the embodiment of a digital experience through virtual reality. These and many other trends are evidence that the IT industry is evolving and growing [11].

Despite the temporary risks in the field of technological information technology, IT companies. they do not have to worry, as the whole economy wants to digitize the state. It is assumed that IT vendors should have created reserves from previous years, and thus it should be easier for them to overcome possible market bottlenecks. Despite this assumption, a number of technology companies were concerned at the start of the 2020 pandemic. Several projects have been suspended or canceled with the new government, but despite the uncertain situation where IT vendors cannot be sure what customers will do under the pressure of the recession, there are ultimately positive prospects for the IT sector.

Two key external factors are emerging, the first of which is the expectation of increasing government IT spending. The second is the need for digitization in various sectors of the economy. Slovakia has a deep-rooted diligence, attention to detail and a responsible approach to work. Therefore, with work efficiency, employees have no problem competing with even the most developed technological countries in the world. Slovakia still has a lot to improve in legislation, but when it comes to the IT sector, for some foreign owners of IT companies, Slovakia is almost a tax haven. Economic conditions are relatively favorable and taxation is similar. However, it must be added that it is certainly not the most advantageous among other countries. The pandemic accelerated the introduction of virtual reality and artificial intelligence into everyday life. Due to the drastic relocation of working meetings,teaching and culture on virtual platforms, there is a great demand for technologies and people who know how to deal with them, as reversing this process is no longer expected. During an pandemic, many events take place online, not only because there is no other option, but also because this form works well and is also more economical and time-efficient. All indications are that information technology will continue to expand rapidly and will require more experts in new areas as well. Software developers, programmers, security IT engineers and technology consultants will find employment in this still young and evolving industry [12, 13].

3.3 Analysis of the IT Sector in the Economies of Selected Countries

The IT sector has been focusing on increased awareness worldwide for several years. The IT sector has a positive effect on the country's economic development and brings the sector to the forefront of the interest of many countries, which leads to an improvement in the very competitiveness of these countries.

We compare the importance of the IT sector in the economies of several countries. Our intention was to compare countries that have the same or similar indicators and characteristics, the analysis of which will give us a relevant view of the importance of the IT sector in these countries. We decided to focus on the Slovak IT sector, which we will compare with other Member States of the European Union—Finland, Denmark and Norway. These are.

3.4 The IT Sector and the Slovak Republic

Over the last ten years, Slovakia has become a leader in the V4 countries in the employment of people working in high- and medium–high-tech and knowledge-intensive industries. In 2019, up to 45.6% of all economically active people in the Slovak Republic worked in such sectors. In second place was Hungary (44.9%), followed by the Czech Republic (44.7%) and then Poland (37.2%). At the same time, the Slovak Republic achieved the most significant jump in the number of employees in the mentioned sectors with "added value". This number has increased by 5.8 percentage points since 2008, bringing Slovakia closer to its pan-European share [1].

With the accession of the Slovak Republic to the European Union, the country has committed itself to the development of the IT sector, which has been on the EU agenda for more than two decades. The eEurope 2002 and eEurope 2005 strategic plans were followed by the 12,010 program, which focused on the convergence of ICT environments in countries and on the creation and shaping of a unified information environment across the EU. The EU 2020 Digital Agenda program replaced the 2010 program. State support for the IT sector is very important for future progress and direction. When countries were in negative economic development, they looked for sectors of the economy that would lead to positive economic growth. Advances in technology and the increasing use of the Internet have begun to point more and more to the information and communication sector. In Slovakia, the IT sector is still not developing at a satisfactory pace, despite the fact that Slovakia has potential.

The automotive industry is considered to be the mainstay of the Slovak economy in almost every situation. The electrical engineering industry sometimes gets this adjective. If indicators such as the volume of production and exports, or the number of employed people are considered a measure, e.g.significant parameters, they have the

adjective "best". But if we look at the individual sectors in terms of other indicators, we will find that the order of importance can change rapidly.

The functioning, efficiency or prosperity of the country are also affected by no less important parameters, including the amount of employee contributions, the amount of income taxes or the amount of VAT they pay. It is also the amount of taxes that companies in individual sectors will pay from their income. The importance of the industry in the country's economy can also be revealed by the unemployment rate of people in the industry. At present, approximately 90,000 people work in the IT sector in Slovakia. According to statistics, the average monthly wage in the IT sector in 2019 was around 1958 euros.

According to the Statistical Office of the Slovak Republic, the average monthly wage of an employee in the Slovak economy in 2019 was 1092 euros. IT jobs are therefore a sought-after contributor to the Treasury. The IT sector is an important pillar of the economy, employing tens of thousands of people and making a significant contribution to social, health and tax contributions. It also contributes to economic productivity growth, as confirmed by former Prime Minister Peter Pellegrini: "Slovakia is an immobile power and will be for a long time to come. As for the production of vehicles per capita, the records will probably be even higher than today, which testifies to Slovakia's dexterity. But this is only one pillar of our industry. I consider the IT sector to be a lower pillar, which has been developing very well here in recent years. There is a huge interest of companies from this segment in coming to Slovakia. Those who are already here are very satisfied and want to expand their capacities. However, they run into a problem, which is a shortage of skilled labor in this area" [8].

4 Results

The IT sector has a strong position in the Slovak economy. In Slovakia, the IT sector is dominated by small companies with 0- 49 employees. However, among the top 10 IT companies, there is only one company with less than 50 employees.

Geographically, the IT industry in Slovakia is concentrated in two centers, in Bratislava, which accounts for approximately 70% of the IT industry, and in the metropolis of the East—in Košice, where the share is approximately 25%. The remaining 5% is divided into other regions, the most important part is around the city of Žilina [10].

According to FinStat, there are a total of 17,122 companies in Slovakia, which we classify in the information technology sector. Figure 2 shows, based on Eurostat data, how the numbers of companies in individual areas of the IT sector are developing.

Every year more and more companies are growing, which proves the growth of this still young industry. Half of the economic crisis in 2009 we see a significant increase in the number of companies. The year 2010 was generally successful for innovative companies due to the favorable environment and relatively calm economy. Among the industrial companies, TV manufacturers Sony and Samsung did better

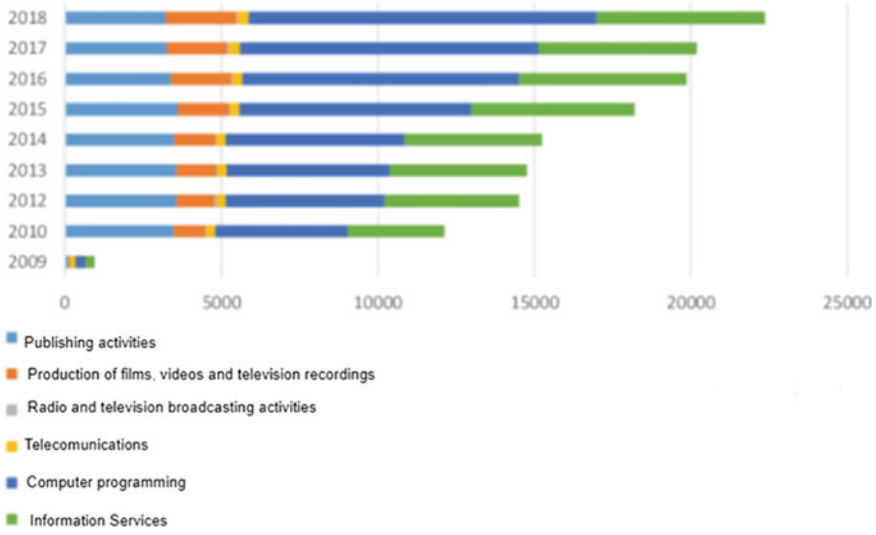

Fig. 2 Statistical classification SK NACE for the period 2009-2018

than expected. This demand was increased especially by the World Cup, which everyone wanted to watch on the new television. Chemical companies and drug manufacturers were among the successful companies. Companies that were not afraid to invest in companies or new acquisitions during the crisis were among the more successful. ESET antivirus has launched new products. The telecommunications company 02, which attracted a large number of customers, also succeeded with attractive programs. We recorded the largest increase in the period under review in companies engaged in computer programming. Telecommunications has proven to be the most stable area. It is the telecommunications companies that benefit from weak competition. Today, the situation is much more favorable for business than before, but the market is still dominated by few companies that have the opportunity to maintain high profitability [11].

4.1 IT Sector and the Nordic Countries

In assessing the Scandinavian countries, Sweden, Finland, Denmark and Norway are considered to be the four key Nordic countries in terms of economic performance, accounting for more than $ 1.5 trillion in world GDP. This makes them the 11th largest economic area in the world.

They have become the home of well-known brands and large global corporations. Economically, the Nordic countries have a lot in common. These are all open economies in which foreign trade is of great importance. They have also rapidly evolved into modern industrial economies that are among the most competitive in

the world. The Nordic countries are among the most developed countries in the Western world. These countries have a higher gross domestic product per capita than the European Union as a whole (see Fig. 3). Performance aspects Norway is at the forefront of th economy. Norway has one of the highest per capita income levels in the world [19].

For Nordic production, digitization and automation can be a window of opportunity for much better and more efficient production. It can be argued that the Nordic countries have more prospects for faster and better implementation of digital technologies than other economies [2]:

- Digital skills and preparedness—Scandinavians are world leaders in the use of digital technologies.

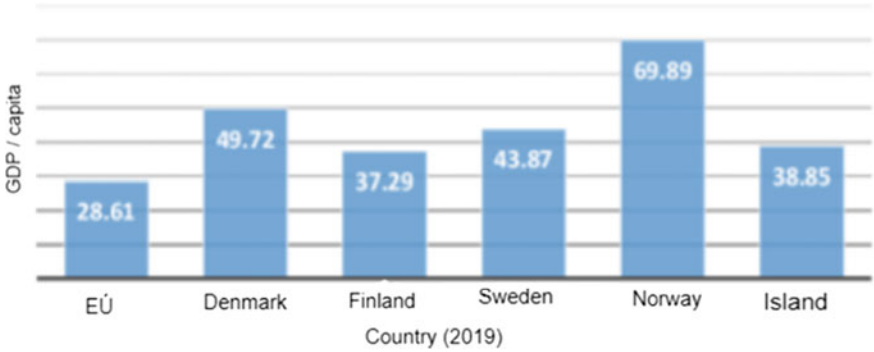

Fig. 3 GDP per capitaAt the same time, the Nordic countries, such as Norway, Denmark and Iceland, have low unemployment rates compared to the EU as a whole (see Fig. 4). The Nordic social model was introduced in the region during the twentieth century. In practice, this means that countries have a large public sector and, as a result, relatively high tax rates. Taxes account for 43% of GDP. Health, social and educational services are publicly funded [20]

Fig. 4 Unemployment rate in 2019

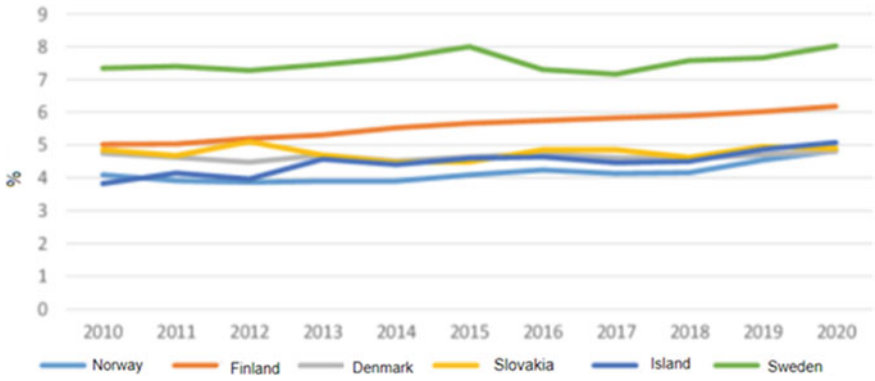

Fig. 5 Share of IT added value in the economy

- Research and development—The Nordic countries are among the countries that spend the most resources on research and development (compared to GDP)—an important prerequisite for the development of new digital technologies.
- A strong ICT sector The ICT sector is an important driving force and its share in the overall scale. employment and value added are high in the Nordic countries (see Fig. 5).

4.2 Comparison of Countries Through Employment in the IT Sector

As the technology industry is interconnected with almost every industry, technologies are and will be increasingly represented in the operation of enterprise systems. It is the IT industry that moves all processes and businesses forward. Companies that have a high level of IT are becoming competitive in the market. IT is currently present in every industry, including retail, design, insurance, banking, aerospace, energy and healthcare. It provides the infrastructure and tools that every organization needs to operate and grow. Therefore, it is understandable that IT companies are growing. Figure 6 shows the development of the number of IT companies for each country.

The largest growth was recorded in the Slovak Republic. In 2018, 26 times more companies in the IT sector were registered in Slovakia than in 2009. We also see an increase in the Nordic countries, but not as sharp as in Slovakia.

IT is one of the most dynamic industries in the industry. In the past, it formed a marginal part of the economic result, but now it is different. The main reason for the increase in the number of employees is the transition of economies from heavy "industry to the gradual automation of production processes. Despite the increase in employment in the sector, market demands are increasing.

We can say that the number of employees in the IT industry has a growing trend. In Slovakia, 41,000 people were employed in IT in 2000, but in 2014 ut IT employed

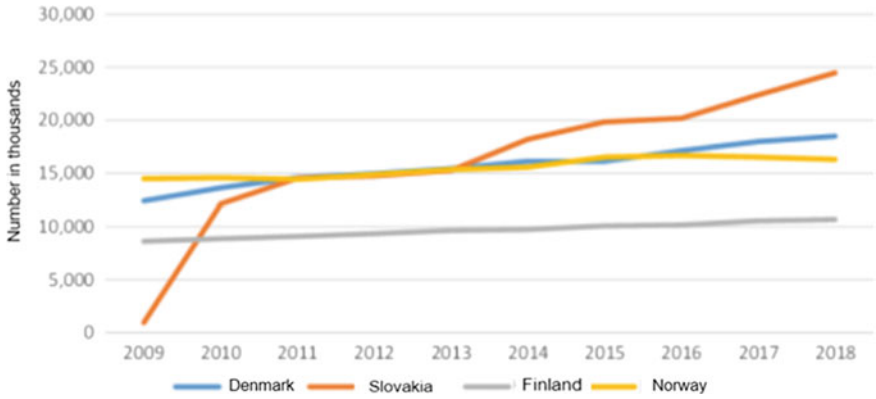

Fig. 6 Development of number of enterprises in IT sector

50,000 employees, an increase of 6,000, and in 2020 it was already more than 90,000. We can say that this is due to the development of the IT sector, which needs more experts every year.

We continue with the analysis of the Nordic countries in the field of employment. At first glance, it can be seen that the number of employees is much higher than in Slovakia (see Fig. 7). The number of employees in Finland was already high in 2014, at 91,000. Most fudi working in IT in proportion Finland has the total number of employees in the country. In 2020, it was approximately 129 thousand.

Another country that will interest us is Denmark. IT employment in this country is relatively high. In 2014, there were 86,000 students working in the industry. In 2016, it was employed around 115 thousand workers and in 2020 the number decreased slightly to 112 thousand.

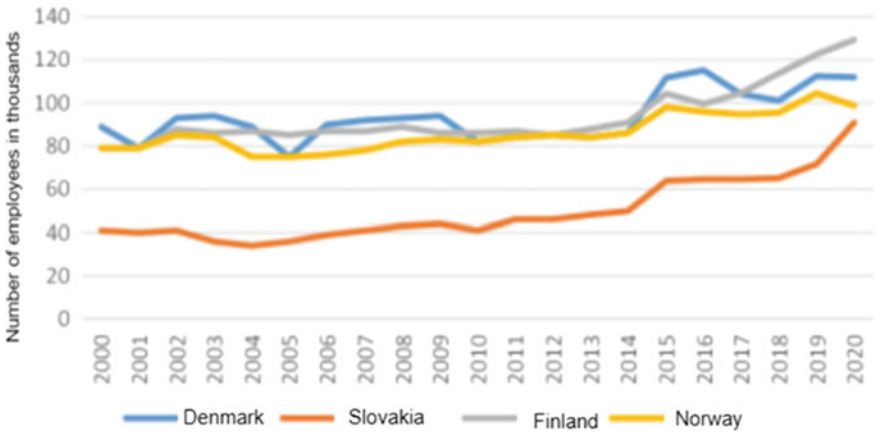

Fig. 7 Development of number of employees in the IT sector

The number of employees in the IT sector is also growing in Norway. In 2000, their value was 79 thousand, in 2014 the IT industry employed 86 thousand employees. In 2020, the companies employ a total of 99,000 students.

Enterprises need designers and developers to create their own hardware, software, multimedia or business applications. Industries need people who can manage and understand IT systems, so they can provide internal or external support. It follows that programmers with general or Professional knowledge is increasingly in demand every year. In each country, the number of programmers or positions related to programming. As the programmer is responsible for designing and creating new software in the programming language, testing the software, creating documentation, and providing technical support, it is irreplaceable in today's world of technology.

5 Conclusions

The information technology sector is a very interesting and dynamic part of the economy, which is worth paying attention to, as we can say that it is the basis for the future of the economies of countries and the world. The IT sector is able to develop very quickly and, importantly, it can adapt to current needs and market trends. Using input–output analyzes, we gradually found out about the role of the IT industry and what position this part has in selected countries of the economy.

The main goal was to point out the importance and position of the IT sector in Slovakia and in selected countries—Finland, Norway and Denmark. In these countries, the IT industry is an important part of the economy, without which the economy would lose a lot of money. If the IT sector was not so developed in the countries, the economy would suffer in several areas in terms of unemployment rates, added value or the creation of a number of new businesses. IT companies make up a substantial part of the country's treasury. Slovakia lags behind selected Nordic countries, but every year it gains strength and thus catches up with these developed countries.

We believe that we have met the set goals and we have managed to bring relevant results in an area that is coming to the forefront of the interest of countries, companies or citizens. The field of information and communication technologies is not so stable that we can say something about it with 100% certainty. Our aim was to objectively assess all the findings, so that they are still supported by analysis, calculation or available data.

References

1. Európska Komisia—Information Society and Media.: Esemeskovanie bez hraníc: Odzvoní vysokým cenám za esemesky v zahraničí (2008)? https://ec.europa.eu/information_society/doc/factsheets/059-roaming-sk.pdf
2. Európska Komisia.: Oznámenie Komisie Európskemu parlamentu, Rade, Európskemu hospodárskemu a sociálnemu výboru a Výboru regiónov—Regulácia a trhy elektronických komunikácií v Európe 2006–2012 (2006). https://eur-lex.europa.eu/legal-content/SK/TXT/?uri=CELEX:52007DC0155
3. Eurostat 1: Hrubá pridaná hodnota v jednotlivých odvetviach (n.d.). https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=naida_10_a10&lang=en
4. Federal Ministry for Economic Cooperation and Development.: IT sector promotion in developing and emerging countries (2011). https://docplayer.net/7581760-It-sector-promotion-in-developing-and-emerging-countries-toolbox.html
5. Homeland Security: Information Technology Sector-Specific Plan.: (2016). https://www.cisa.gov/sites/default/files/publications/nipp-ssp-information-technology-2016-508.pdf
6. ISTP – Internetový sprievodca trhom práce.: Dopyt po IT pracovníkoch stale rastie, stúpli im aj platy (2018). https://blog.istp.sk/dopyt-po-it-pracovnikoch-stale-rastie-stupli-im-aj-platy/
7. Nováková, I.: študijny materiál SŠ, Obchodná akadémia, Stará Ľubovňa (2017)
8. Orange Slovensko.: Výročná správa spoločnosti Orange Slovensko za rok 2012 (2012). https://www.orange.sk/fileadmin/orange/user_uploads/dokumenty/onas/tlacove-centrum/vyrocne-spravy/vyrocna_sprava_2012_sk.pdf
9. Techopedia: Information Technology (IT).: (2021) https://www.techopedia.com/definition/626/information-technology-it
10. Telecom Slovakia.: Výročná správa spoločnosti Telekom Slovakia za rok 2009 (2009). https://www.telekom.sk/documents/10179/44166/rs2008sk.pdf/971780a5-6782-4e33-8a06-199135402dd4
11. Telecom Slovakia.: Výročná správa spoločnosti Telekom Slovakia za rok 2013 (2013). https://www.telekom.sk/documents/10179/44166/Slovak+Telekom+Ro%C4%8Dn%C3%A1+spr%C3%A1va+2013.pdf/3129b031-d165-4924-9ad9-5ed7bcabc204
12. Touchsupport: Information technology fields and sectors explained. (2013). https://www.touchsupport.com/information-technology-fields-sectors-explained/
13. Štatistický úrad SR_3: Priemerný počet zamestnaných osôb podľa ekonomických činností SK NACE REV. 2 (2021). http://datacube.statistics.sk/#!/view/VBD_SLOVSTAT/pr2051qs/v_pr2051qs_00_00_00_sk
14. Štatistický úrad SR_3: Priemerný počet zamestnancov v odvetví C26—Výroba počítačových, optických a elektronických výrobkov (2021). http://datacube.statistics.sk/#!/view/VBD_SLOVSTAT/pm2005qs/v_pm2005qs_00_00_00_sk
15. Štatistický úrad SR_3: Priemerný počet zamestnancov v jednotlivých častiach IT zameraných na obchod (2021). http://datacube.statistics.sk/#!/view/VBD_SLOVSTAT/ob2005qs/v_ob2005qs_00_00_00_sk
16. Štatistický úrad SR_4: Priemerný počet zamestnancov v jednotlivých častiach IT sektora v odvetví J—Informácie a komunikácia (2021). http://datacube.statistics.sk/#!/view/VBD_SLOVSTAT/ik2005qs/v_ik2005qs_00_00_00_sk
17. Štatistický úrad_5: Priemerná mesačná mzda v odvetví C26 – Výroba počítačových, optických a ekektronických výrobkov (2021). http://datacube.statistics.sk/#!/view/VBD_SLOVSTAT/pm2002qs/v_pm2002qs_00_00_00_sk
18. Štatistický úrad_10: Tržby za vlastné výkony a tovar v jednotlivých častiach IT sektora v odvetví J—Informácie a komunikácia (2021). http://datacube.statistics.sk/#1/view/sk/VBD_SLOVSTAT/ik2008qs/v_ik2008qs_00_00_00_sk
19. Štatistický úrad SR_11: Vybrané ukazovatele za telekomunikácie (2021). http://datacube.statistics.sk/#!/folder/sk/1001110
20. Štatistický úrad SR_12: Vyvoj priemernej mesačnej mzdy na Slovensku (2021). http://datacube.statistics.sk/#!/view/sk/VBD_SLOVSTAT/np2018qs/v_np2018qs_00_00_00_sk

21. Štatistický úrad Slovenskej republiky.: Štatistická klafikácia ekonomickývh činností SK NACE Revision 2 (2007). https://www.financnasprava.sk/_img/pfsedit/Dokumenty_PFS/Podnikatelia/Clo_obchodny_tovar/EORI/StatistickaKlasifikaciaEkonomickychCinnosti.pdf
22. Workie Tiruneh, M.: Vplyv informačných technológií na ekonomický rast a zamestanosť: teoretické a empirické pohľady: (s aplikáciou na efekty komerčného modelu Microsoft Slovakia na slovenskú ekonomiku). Bratislava: Ústav slovenskej a svetovej ekonomiky SAV (2004). ISBN 80-7144-141-4