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Edited by

Jan Ministr, Roman Kozel

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Jan Ministr, Roman Kozel

**Information Technology for Practice 2022
(IT4P-2022)**

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Sponsors of IT for Practice 2022



EUNIS - CZ

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VŠB Technical University of Ostrava - Centre for Information Technology



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FOREWORD

Conference on Information Technology for Practice 2022

Ladies and gentlemen, you are receiving the proceedings of the traditional international conference IT for Practice 2022 (IT4P), which was organized as the 25th year. Due to the ongoing pandemic situation in the Czech Republic and the tense international situation in Ukraine, despite these limitations, we decided to organize the 25th annual conference in the traditional format with direct participation in Ostrava to meet in person in the pleasant environment of the VŠB - Technical University in Ostrava. I would like to thank all the participants from , who presented their papers from the Czech Republic, Slovakia, Poland and Ukraine.

The conference was organized by the auspices of EUNIS-CZ (Association of European University Information Systems of the Czech Republic), ČSSI (Czech Society for System Integration), CIT (Center for Information Technologies VŠB-Technical University of Ostrava) and IT Cluster z.s. The conference is appreciated within the European Union for its content focused on the practical use of information technology. The organizers are trying to register this conference in recognized databases.

According to the title of the conference, the participants come from academic staff, managers and employees of ICI, IS designers in companies and institutions, ICT providers and students. The topics of this year's conference are:

- Information Society and Education;
- Information Management and IT Innovation;
- Digitalization of public administration;
- Information Security.

The purpose of the organizers is to create a platform for the exchange of knowledge and skills in the field of ICT innovation and the use of new knowledge in practice, as it is not easy to attract professionals willing to share their experiences.

Thanks also to all sponsors who contributed to the financial support of the conference.

We wish you successful use of the professional contacts and information you obtained at the conference in solving specific problems in your companies and institutions.

On behalf of the organizers



Jan Ministr

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INFORMATION SOCIETY AND EDUCATION

Multi-criteria evaluation of the presentations

Blanka Bazsová¹, Marek Štěpán², Martin Špaček³

Abstract. The paper evaluates groups of presentations of the subject taught at VŠB-TU Ostrava using the multicriteria method, the analytical hierarchical process method (AHP). The three presenters' presentations were evaluated using a set of criteria. Two decision-makers evaluated the presentations according to the proposed criteria and sub-criteria. Based on the first decision maker's evaluation, the lecturer's second group of presentations was determined to be the best. The second decision maker scored third group of presentations to be the best out of the three presentations.

Keywords: Analytic Hierarchical Process, criteria, decision making method, lecturer, presentations.

JEL Classification: C44, D19

1 Introduction

With the emergence of the Covid-19 epidemic the importance of the presentations has increased in teaching. Presentation represents the transfer of information in a simplified form from the presenter to the recipient (Kabátek, 2010). By presentation we mean an opportunity to bring, present, show ideas, and opinions. In case of education, the transfer of knowledge from the lecturer to the audience is important. Improving presentation skills is required. Hasegawa et al. (2008) state that presentation helps researchers and students to share, reuse and improve their documents. Presentations should be well-organized to achieve the set of goals. According to Medlíková (2010), in practice, there are several types of presentations: data presentation, product presentation and motivational presentation. The data presentation aims to inform, communicate, and educate. It can be a report, for example, on the status of a project, a lecture on a given topic, an introduction to new laws, etc. The advantage of this presentation can be a summary of the state of affairs; the disadvantage is the low interest of the audience. The goal of the product

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presentation is to impress, propose and solve. In this type of presentation, logical argumentation of ideas is appreciated. Motivational presentation requires as a prerequisite for a success to be aware of the group of listeners.

2 Analytic Hierarchical Process Method (AHP)

The Analytic Hierarchical Process Method (AHP) is a multi-criteria decision method which was founded by Saaty. Saaty (2006) expects that according to the criteria, it is possible to evaluate the variants. The criteria can be grouped according to the various aspects. AHP method is possible to apply in many fields. Authors of this paper have applicated the AHP method in ICT field yet. Bazsová and Štěpán (2021) made the evaluation of the simulation software tools. The measurement of employee performance was carried out in a paper of Bazsová (2016).

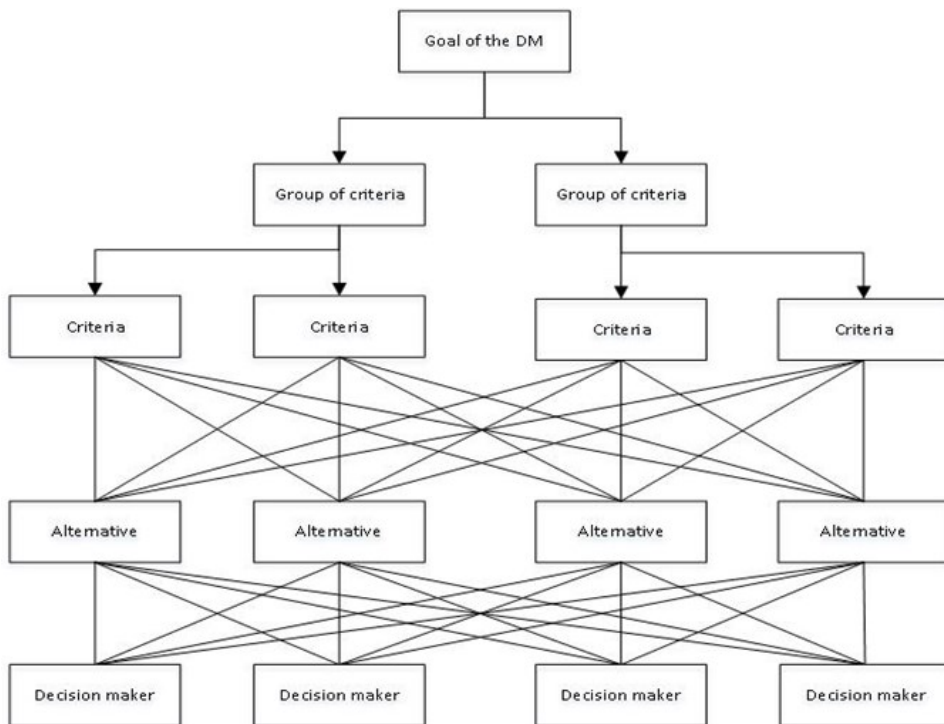


Figure 1: Fundament of the AHP method (Source: Saaty, 2006; adjusted)

Saaty proposed the evaluation of the criteria according to the rule between i and j elements (see Table 1).

Table 1: Saaty's criteria evaluation, **Source: Saaty, 2006**

Value	Criteria Evaluation
1	equal importance among elements i and j
3	moderate importance of i element before j element
5	strong importance of i element before j element
7	very strong importance of i element before j element
9	the extreme importance element i before j

The collection of criteria is divided into groups which are called super-criteria and the amount of criteria that are subordinate, i.e. they are subgroup. So we can create the tree of criteria and variants, which are evaluated by decision maker. The fundament of this division is shown in Figure 1.

Each level of criteria in each group is evaluated separately. There is necessary to calculate the consistency ratio. Consistency is evaluated by the ratio of consistency (CR). The consistency value must be $CR < 10\%$, where:

$$CR = \frac{CI}{RI} \quad (1)$$

where RI is the random index.

When

$$CI = \frac{\lambda_{max} - n}{n - 1} \approx \frac{w_i}{w_j}, \quad (2)$$

where λ_{max} is the own number and n is number of criteria.

The weight of each criteria according is based on the equation:

$$\frac{(\prod_{j=1}^n s_{ij})^{1/n}}{\sum_{j=1}^n (s_{ij})^{1/n}} \quad (3)$$

The final option rating is then expressed in the following equation.

$$U_i = \sum_{j=1}^k u_{ij} \times w_j, \quad (4)$$

where U_i is calculated as overall significance of variant i with respect to the objective of the decision-making process, u_{ij} expressed the significance of

the variants for the individual criteria and w_j expresses the significance j of that criterion (Bazsová, 2016; Ramík and Perzina, 2008).

3 Results and discussion

For the preparation of the assessment it is necessary to create the tree of criteria. It has chosen 2 global criteria, content criteria and appearance criteria. In the second level, there were six content criteria – structure of presentations, examples, use in practice, number of slides, number of presentations and comment. The partial appearance criteria were: quality of images and tables, text size.

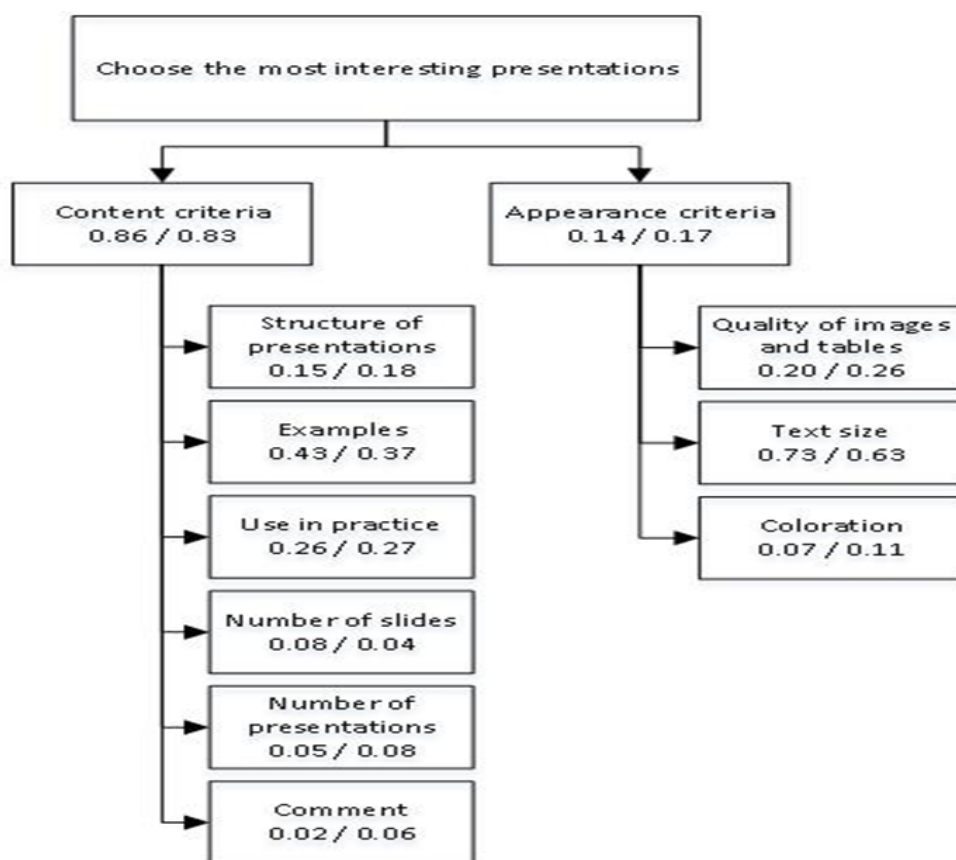


Figure 2: Evaluation of the proposed tree of the criteria by using AHP. (Source: own processing)

The evaluation was conducted by two decision makers, Ph.D. student and teacher. The reason lies in the fact that the 1st decision-maker (Ph.D. student) has already completed lectures and presentations and knows the importance of the issue of the given subject. The 2nd decision-maker (teacher) who participated in the decision-making process practices the given course.

The mutual comparison of the importance of the nine proposed criteria can be compared using a scale, which in this case was 9 degrees. Table 2 shows the calculated local and global weights of the individual criteria. The mutual assessment of importance is based on the evaluation by using of the Saaty's matrix. This evaluation was provided according to both decision makers. From Table 2 and Figure 2, according to the calculated global weights for the super-criteria, it follows that more importance is placed on the content side than on the appearance side.

Table 2: Evaluation of criteria by using Saaty's matrix
source: own calculation

	DM1		DM2	
	LW	GW	LW	GW
C11	0.15	0.13	0.18	0.15
C12	0.43	0.37	0.37	0.31
C13	0.26	0.23	0.27	0.23
C14	0.08	0.07	0.04	0.03
C15	0.05	0.04	0.08	0.07
C16	0.02	0.02	0.06	0.05
C21	0.20	0.03	0.26	0.04
C22	0.73	0.10	0.63	0.11
C23	0.07	0.01	0.11	0.02
C1	0.86		0.83	
C2	0.14		0.17	

Table 3 shows the evaluation of three blocks of presentations that were suggested by three teachers who lectured according to these presentations.

The evaluation was provided according to the two decision makers, Ph.D. student and teacher.

All suggested criteria were maximized. Table 3 shows the evaluation of the variants according to the AHP process. The process required transformation into a normalized form and assessment of partial and total utility according to weights. The results showed that the most interesting presentations were the block of presentations by the second lecturer according to the first decision-maker (Ph.D. student - 0.405) and the third block of presentations according to the second decision-maker (teacher - 0.387). Both decision makers marked the first block of presentations in third place. First and second place were determined differently by the decision-makers. Multi-criteria evaluation of the presentations revealed advantages, such as comparing the best group of presentations with other presentations. The lecturer can thus improve other presentations according to the best group of presentations.

Table 3: Variants Assessment by using AHP method
Source: own calculation

	DM 1			DM 2		
	V1	V2	V3	V1	V2	V3
C11	0.038	0.064	0.026	0.045	0.030	0.074
C12	0.114	0.142	0.114	0.078	0.130	0.104
C13	0.057	0.094	0.075	0.056	0.075	0.094
C14	0.016	0.032	0.024	0.007	0.019	0.007
C15	0.008	0.020	0.012	0.012	0.024	0.030
C16	0.010	0.004	0.008	0.022	0.008	0.017
C21	0.006	0.015	0.007	0.009	0.022	0.011
C22	0.021	0.031	0.052	0.026	0.035	0.044
C23	0.005	0.002	0.002	0.009	0.005	0.005
Total:	0.274	0.405	0.321	0.265	0.348	0.387
Order	3	1	2	3	2	1

4 Conclusion

Multi-criteria evaluation is applied in practically all areas of life. This AHP evaluation has simplified decision making in the educational process area. It revealed possibilities for subsequently improving the presentations. The evaluation of the presentations, which was carried out by two decision-makers (Ph.D. student and teacher), confirmed approximately the same importance of the selected criteria.

Acknowledgements

This paper was supported within SGS project SP2022/74 „Computational Intelligence in the Prediction of Economic Quantities, Data Mining and Economic Process Modeling”.

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ICT skills as accelerator of achievement of SDG of the 2030 Agenda

Emília Duřová Spiřáková¹, Barbora Gontkoviřová²

Abstract. Need to have and improve ICT skills is becoming an essential requirement for young students and also for a large part of the employed population, which had to adapt to the unfavorable situation from day to day and start working from home, in the current situation affected by the COVID-19 pandemic. Students, employees, entrepreneurs and the public administration realized the importance and need of using information and communication technologies. Paradoxically, this situation can help to get closer to one of the SDG of the 2030 Agenda, which is to significantly increase the share of young people and adults with skills in the field of information and communication technologies by 2030. They are an absolute prerequisite for a wide range of professions, honorable job classification and for business. The aim of the article will therefore be to analyze the ICT skills of individuals in EU member countries, to point out disparities between countries and to evaluate the impacts of the COVID-19 pandemic in the monitored area.

Keywords: SDG, education, digital skills, gender gap

JEL Classification: J24, O15, D83

1 Introduction

The last two years affected by the pandemic caused by COVID-19 contributed to an increase in the emphasis placed on the use of information and communication technologies in most spheres, not only in the economy. Individuals were dependent on a good Internet connection, which enabled them to carry out a large part of their work, or study directly from home. The need for a high-quality Internet connection only intensified at that time, even though the Europe 2020 strategy had already been dealing with this issue since 2010 as part of its Digital Agenda for Europe initiative. One of the main

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efforts was to promote digital literacy for all regardless of age and gender (EC, 2010).

In 2015, all UN Member States adopted the Sustainable Development Goals (SDGs) as part of the 2030 Agenda. SDGs are a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere. (UN, 2022). Of the 17 main goals, within the 4th goal focused on Quality education (Figure 1), is partial target 4.4 oriented on ICT skills. Namely, by 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship. The basic indicator that is monitored in connection with the fulfillment of the stated partial target is Indicator 4.4.1: Proportion of youth and adults with information and communications technology (ICT) skills. In addition to basic ICT skills, such as turning on a computer, using hardware to print and copy documents and using digital cameras to capture photographs or video footage, making video calls, searching on the internet or using a mobile device like a tablet or phone we can include to extended ICT skills technological knowledge, online research, social media management, netiquette, data management, desktop publishing, word processing, collaboration, problem solving and organization.

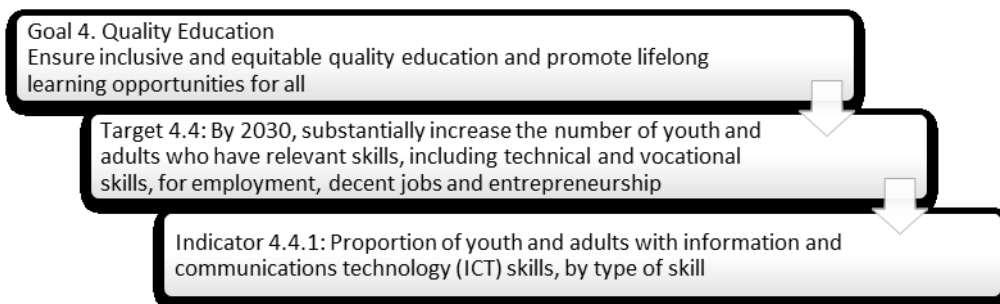


Figure 1SDG and ICT skills, Source: Own processing based on UN, 2022.

According to the Eurostat digital skills are a key indicator in the European Commission's Digital Decade initiative. This outlines the EU's vision for digital transformation by 2030. Goals include at least 80% of EU citizens aged between 16 to 74 having at least basic digital skills by 2030.

Based on the stated facts, the aim of the article will be to analyze the ICT skills of individuals in EU member countries, to point out disparities between

countries and to evaluate the impacts of the COVID-19 pandemic in the monitored area. The article will also include tracking gender differences in ICT skills before and during the pandemic.

2 Theoretical framework

The current period affected by the COVID-19 pandemic has changed the demands on ICT skills of individuals. People have to adapt to the increasing demands for these skills in most occupations. It is a consequence of the growing demands for workforce in the labor market. An important role in this is played by the educational system in countries, whether at the level of primary or secondary education, respectively formal or nonformal education. Figure 2 therefore shows the position of ICT skills in relation to assumptions for ICT skills development and also to labor market.

Education systems are responsible for addressing the skills gap. They should ensure that young people leave school with the digital skills required by society and economy. To date, most national curricula, even in high-income countries, do not reflect the skills needed for the digitalized economy (Charles, Xia and Coutts, 2022). Also, the results of study realized by Pařur Aniřić and Buřelić (2021) indicate that there should be a shift in ICT education regarding the inclusion within curricula and learning outcomes, from something that is "suitable" to "necessarily". Bhandari, Jain, and Sahu (2021) confirmed the positive association between the provision of functional computers at secondary schools and the attainment of digital skills, even for students from households with no computers at home. A key policy recommendation is that providing computers at schools can help overcome barriers to access to digital devices at home and improve the attainment of digital skills.

Basic factors supporting ICT skills also include internet connection. In case of lack of acquired ICT skills within formal education, different forms of trainings aimed at developing ICT skills can be used.

Gaining digital skills during the education process is important because it is one of the foundational skills that help prepare students transition to work and prepares them for life (Bhandari, Jain and Sahu, 2021). Due to growing digitalization of the economy and the labor market, the demand for ICT skills and their use in the workplace has increased (Acemoglu and Autor 2011),

that means the current labor markets require more advanced digital skills (Charles, Xia and Coutts, 2022). As a follow up to that digital skills are increasingly being recognised as a key foundational skill that also enhances employability (Bhandari, Jain and Sahu, 2021).

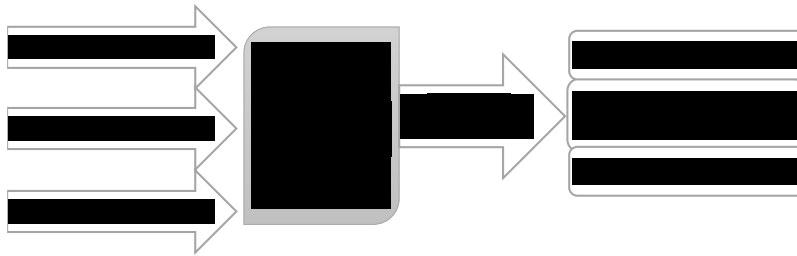


Figure 2 Factors affecting ICT skills and the impact of ICT skills on the labor market, Source: Own processing.

3 Methodology

The following analysis is based on secondary data from the Eurostat statistical database. The choice of the data source was based on the requirement of the comparability. The indicator of Share of individuals having at least basic digital skills was used. It measures the share of people aged 16 to 74 having at least basic digital skills. Digital skills indicator is a composite indicator based on selected activities performed by individuals on the internet in the specific areas: until 2019, these included information, communication, problem solving and software and from 2021 onwards an additional area, safety, was added. To verify whether there has been a significant change in the given area, we compare the value of the indicator for 2015 and 2021.

Data normality assessment is a prerequisite for many statistical tests and parametric testing options. Data normality was tested by the Shapiro-Wilk test for a significance level of $\alpha = 0.05$. Paired T-test is used to assess the statistical significance of differences in dependent samples, in our case the values of the share of individuals having at least basic digital skills in EU member states in 2015 and 2021. The statistical significance of the differences was tested at a significance level of $\alpha = 0.05$. If the p-value is lower than α , then the null hypothesis is rejected.

Gender differences in the various indicators can be described in more detail by means of a gender gap, which is calculated as follows:

$$\text{gender gap} = U_m - U_f \quad (1)$$

where U_m represents the value of the indicator in the male category and U_f represents the value of the indicator for the female category.

A positive gender gap means that men achieve a higher value in the monitored indicator. On the contrary, a negative gender gap informs us that females recorded a higher value in the indicator. In assessing the statistical significance of gender differences, the T-test for independent samples was used. The statistical significance of the differences was tested at a significance level of $\alpha = 0.05$, whereas it holds, if the p-value is lower than α , then the null hypothesis is rejected.

4 Results and discussion

In this part of the article, we will point out the disparities in having at least basic ICT skills in the individual member countries of the European Union and we will point out whether the pandemic caused by COVID-19 had a statistically significant impact on the monitored area. It will also include tracking gender differences in having at least basic ICT skills in the period before and during the pandemic.

Based on the data available from Eurostat, we can state that in the northern countries of the European Union in 2021 was reported the highest proportion of individuals aged 16-74 who have at least basic ICT skills in the total number of individuals of the given age category (Figure 3). Almost 80% was in the Netherlands and Finland, followed by Ireland (70%), Denmark (69%) and Sweden (67%), which is well above the EU average (54%).

On the contrary, in 2021, the smallest share of individuals with at least basic ICT skills was in the southern countries of the European Union, namely in Romania (28%) and Bulgaria (31%).

Ireland clearly belongs to the countries in which the greatest progress in this area has been recorded since 2015, as the share of individuals increased by up to 26% during the monitored period. The pandemic contributed significantly to this fact, which forced the country's inhabitants to use ICT to a much greater extent. On the other hand, there are countries in which there has been a significant decrease in the share of individuals having at least basic ICT skills since 2015. These are Luxembourg, in which the indicator decreased by

22% and Germany with a decrease of 18%, which meant a decrease in the indicator to 49% population.

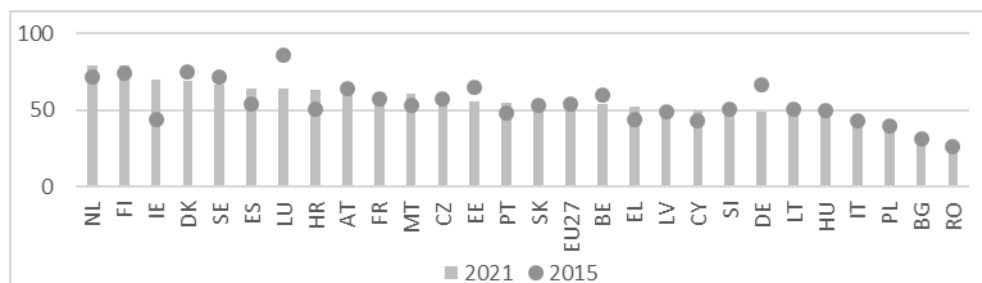


Figure 3 Share of individuals having at least basic digital skills (in %), Source: Own research.

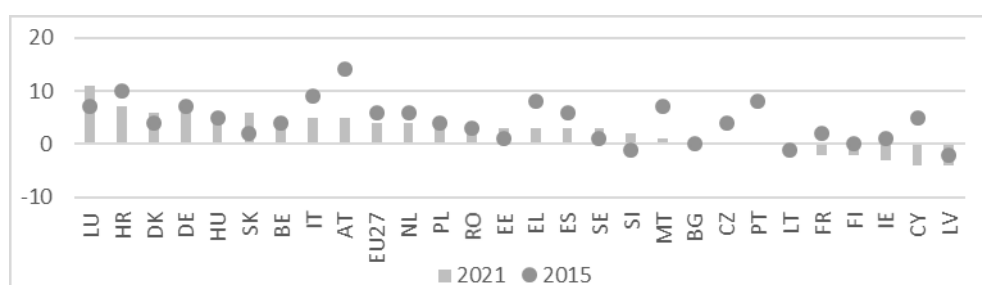


Figure 4 Gender gap in share of individuals having at least basic ICT skills, Source: Own research.

To fulfill the aim of the article, it is necessary to monitor the gender gap in share of individuals having at least basic ICT skills (Figure 4). In 2021, the highest gender gap was reported in Luxembourg (11%), while in 2015 it was Austria (14%). The Czech Republic and Portugal are countries that in 2015 showed a noticeable gender gap in share of individuals having at least basic digital skills, but in 2021 the differences between men and women in this area have completely equalized.

On the other hand, a negative gender gap in the monitored indicator was shown in 2015 by three member countries of the European Union, namely Lithuania, Latvia and Slovenia. Gradually, and most likely due to the impact of the pandemic, the number of countries with negative gender gaps increased, and in 2021 they were Ireland, France, Lithuania, Latvia and even Finland. It means that in these countries a greater proportion of women have at least basic ICT skills compared to men aged 16 to 74.

The statistical significance of the differences in the monitored sample of countries in 2015 and 2021 can be assessed by tests, which is preceded by a normality test (Table 1). Since our data follow normal distribution, parametric tests (T-test) are used to compare the samples.

The T-test for the two paired samples was used for the share of individuals having at least basic digital skills in 2015 and 2021 (Table 2). Based on the test results of paired samples ($p > \alpha$), the null hypothesis could not be rejected. "Average share of individuals having at least basic digital skills in EU member states is comparable in both years." Despite the differences between countries and also the impact of the pandemic, year-on-year changes in the share of individuals having at least basic digital skills are not statistically significant.

Table 1: Data normality test, Source: own research

Shapiro-Wilk Test						
	Total 2015	Total 2021	Males 2015	Females 2015	Males 2021	Females 2021
W-stat	0.9786	0.9649	0.9757	0.9828	0.9700	0.9779
p-value	0.8305	0.4748	0.7552	0.9201	0.6012	0.8116
alpha	0.05	0.05	0.05	0.05	0.05	0.05
normal	yes	yes	yes	yes	yes	yes

In an effort to highlight gender differences, the comparative analysis was supplemented by the T-test for two independent samples (Table 2).

Table 2 Test for independent samples and Paired T-test, Source: own research

	T Test: Two Paired Samples 2015 vs. 2021		T Test: Two Independent Samples Males vs. Females 2015		T Test: Two Independent Samples Males vs. Females 2021	
	One Tail	Two Tail	One Tail	Two Tail	One Tail	Two Tail
p-value	0.2120	0.4241	0.1355	0.2709	0.2270	0.4541
t-crit	1.7056	2.0555	0.0000	0.6792	1.6747	2.0066
lower		-5.1004		1.6450		-4.1816
upper		2.2115		6.7995		9.2186
sig.	no	no	yes	yes	no	no

The share of males and females having at least basic digital skills in 2015 and 2021 was compared. In case of 2015, the test confirmed statistically significant differences between the genders. In 2021 gender differences is not statistically significant. This is a positive change from the point of view of eliminating the gender gap.

5 Conclusions

The results of the performed analyzes pointed to differences in having of ICT skills available between 2015 and 2021, especially between the northern and southern countries of the European Union. The reason of these differences can be the support and investment in ICT by government. It has a great impact on sustainable development (Tyagi, et al, 2020).

In order to fulfill the aim of the article, it was also tested a statistical significance of gender differences in having at least basic ICT skills in EU27. Current studies skills (Charles, Xia and Coutts, 2022) suggest that both men and women could face equal job displacement and potential gains due to digitalization. Patriarchal cultures, the stereotype of technology as a male domain and a biased social and educational environment are the main factors of the gender gap in digital skills. While gender divides in digital skills are severe in a global context (Tyagi, et al, 2020), based on our results the gender gap in the share of individuals having at least basic digital skills in EU27 is not statistically significant. It can be concluded that the EU27 countries have successfully dealt with gender differences between men and women possessing at least basic ICT skills in recent years.

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Customer relationship management to support the customer experience

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Abstract. The business must have a chance for an optimal solution of internal processes and a user-friendly environment supporting the customer experience. The most promising solution comes from automation and artificial intelligence (AI). It is accessibility, digital assistance, error minimization, and decision support using multiple criteria. This article focuses on the availability and breadth of code-free AI tools that enable an environment for visualization and data analysis using hundreds variables and data points. The method approach is based on literature research and practical work with the selected. Information technology offers dozens of AI tools. Many of them have started a free trial or a free version. Well-know solutions take a comprehensive approach, such as Google AI and Microsoft Azure AI. There are also smaller ones like IBM Watson with question-answering features or Gyana with linear regression models.

Keywords: Customer relationship management, customer experience, information technology, artificial intelligence.

JEL Classification: D8; C8; M3

1 Introduction

Customer behavior changes over time. Maintaining a relationship with customers, knowing customer expectations and providing customer service is necessary for business. Self-service is one of the most popular customer service requests. This is natural because no one wants to wait for an answer when the problem may be taken care of own skills. A good helper is live chat with the support of artificial intelligence to increase orientation. Of course, it is necessary to remember classic communication through representatives or e-mail.

Implementing artificial intelligence in CRM (Customer Relationship Management) helps to be more proactive in customer care. It is about identifying potential problems, predicting their occurrence and offering the

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most optimal solution in order to get a better positive experiences from customers (Louveau, 2022).

2 Customer experience

Customer experience helps differentiate the goods and services offered from other suppliers and competitors. This is important because quite a lot of goods are similar, or identical. The following numbers show the current situation in customer service (Todorov, 2022; Morgan, 2019). It is about the value of the customer experience for brand loyalty, quality of life, higher revenue or repeat purchases:

- 96% of customers declare that customer service is important for brand loyalty;
- 77% of consumers report that inadequate customer experiences have a negative impact on quality of life;
- loyal customers are five times more likely to buy again;
- companies that take care of customer experience have 4-8% higher sales;
- companies with customer experience monitoring have the ability to outperform others by 80%;
- 84% of companies report a relationship between improving customer experience and increasing revenue.

CRM systems (Chauhan, 2022) offer optimal support for customer care. There are examples of good practice and recommendations for enhancing the customer experience to promote brand loyalty and uniqueness. The following list shows only a fragment of the many recommendations and declarations of trends (Basu, 2020; Morgan, 2019):

- integration clustering tools such as impact report into CRM to learn more about recurring events that may be difficult for the customer;
- seeking innovation for new methods to improve specified problem issues;
- knowledge of current CRM trends and the possibilities of artificial intelligence (AI) or virtual agents;
- the use of back-office systems such as CRM to support the care of personalizing the customer experience;

- automation of usage to ensure the overall customer journey with better ways to streamline the customer experience.

In many tasks and recommendations, there is a help to use automation and artificial intelligence (Duggal, 2022) with many advantages such as 24x7 availability, digital assistance, error minimization and decision support using multiple criteria. Uniqueness is related to the ability to make optimal decisions faster and more accurately than humans (Marr, 2021) with an impact on competitiveness (Zoroja and Bach, 2016). Another advantage is the search for hidden facts from data structures, where data processing works with hundreds variables and data points for optimal decision-making.

IT users have a better experience with the self-service option that information technology offers through the IT interface. Code-free interfaces are available for creating programs and interactive systems with graphic elements. Code-free integrated AI systems have the ability to create the necessary modules. One may say that it is, for example, a drag and drop process (Sway AI, 2022) or wizard-based method (Akkio, 2022). Azure Machine Learning Designer (Azure, 2022) from Microsoft and Appian (Appian, 2022) are well-known in this area.

3 The instant solution from AI

Current trends are connected to instant solutions and very popular code-free tools are visible when creating website with chatbot implementation, mobile applications, database management or sending newsletters via Mailchimp. The above examples are just a fragment of many. Code-free AI tools are growing and are a much newer business (Akkio, 2021; Artificial Intelligence Software with a Free Trial, 2022). Artificial Intelligence has been implemented in many tools such as AI coding assistants, AI image generators, AI writing, AR training, chatbots, computer vision, data labeling, deep learning, eye tracking, intelligent virtual assistants, IoT (Internet of Things), machine learning, voice-bot, or virtual reality training. Please see table 1.

CRM systems need to use AI to optimally analyze stored data to know more about customer behavior and experience. It is about the growing sales trend, the appropriate conversation, and the power needed for big data. Key skills focus on the necessary data sets from the CRM database and work with them.

AI care automates routine CRM background tasks. IT users evaluate machine learning, predictive modeling, statistical and mathematical tools, an algorithm library, model training, and templates with visualization.

Table 1 Code-free AI tools, Source: own.

Code-free AI tools	Description	Advantage
Akkio	platform for creating and integrating AI models without technical expertise	building AI flow with visual interface (Akkio, 2022)
Apteo	tool for segmenting the customer base and predicting their behavior	learning about customer behavior (Apteo, 2022)
Google AI	tool to create a data segment, set a training budget, and manipulate various settings	complex solution (Google AI, 2022)
Gyana	tool for visualization the data analysis process based on data preparation, graph and map models, and reports creation	linear regression models (Gyana, 2022)
IBM Watson	solution for supporting machine learning models, training, and deployment	question-answering functions (IBM Watson, 2022)
Microsoft Azure AI	uploading the dataset, working with the prediction, and running the model	complex solution (Azure, 2022)
One AI	running the processing software	various models (One AI, 2022)
Peltarion	AI model works with a large number of metrics and settings	complex features (Peltarion, 2022)
PredictNow.ai	AI solution with an interest in financial machine learning	profit and investment (PredictNow.ai, 2022)
Prevision	AI modeling based on data upload, model training, performance analysis and predictions generation	data science (Prevision, 2022)

The default method for prediction is based on data collection and cleaning, survey and analysis, creation of the necessary model and evaluation (Lateef, 2022). The process is complex and manual work with data at each stage is limited by skills; there are mistakes and misunderstandings. In this situation, code-free AI tools help to work with big data and build models with disproportionately little effort.

4 Conclusion

This article focuses on the possibility of integrating AI for CRM to support a better customer experience. It is about the optimal implementation of information technology to have a suitable background for business processes. The pressure is on timing, quality and avoiding potential problems. One of the trends of 2022 is artificial intelligence and its use for CRM. Available statistics show the numbers on the importance of customer experience for brand loyalty and quality of life for higher sales and repeat purchases. Benefits come from instant or self-service solutions such as code-free AI tools. AI has the ability to create the necessary models and IT users use a drag and drop process or templates. Comprehensive solution such as Microsoft Azure AI and Google AI are well-known, but businesses have the option to choose from others such as Akkio, IBM Watson, or Peltarion.

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Methodology of improving performance by way of defining an efficient position of a school social workers

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Abstract. These days are witnessing increasing debates over the influence of the society when providing equal opportunity for education with emphasis on the individual trades and personal development of the students in creating a high-quality social climate in schools. We can state that the on-going transformation of the education system is related mostly to the dynamic tempo of life and its overall development, which logically were causing the population to face higher requirements in terms of higher demands on flexibility, productivity, onset at work and requirements for life-long education. By initiating these changes and adapting to the new conditions, higher demands are set for the adult population, whereby of no less effect for young people, who are already encountering them e.g., in via new forms of teaching at schools. The contribution is oriented on mapping the competencies and demands on the social pedagogist in the Slovak system of education. Based on the facts as above, we have decided to take a closer look the importance of the social pedagogues, his or her role in the system of education and investigate the potentials of instituting this position into the Slovak educational environment along with the suggestions for the necessary extent of education in social work at schools.

Keywords: school social work, socio-pathological phenomena, prevention, school social worker, effectiveness, competence.

JEL Classification: C31, O35, Z13

1 Introduction

In line with the development of the society there came to the growth of socially negative phenomena, the very area social work is interested in. The changes taking place in the society have been adequately reflected in the

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development of the profession of the social worker. In his or her everyday work the social worker is bound to react to various situations and problems and carry out the responsibilities both toward the society as a whole and to the individual clients as well. All that posing substantially high requirements. The demands are covering a comprehensive set of requirements established for this profession that social workers must meet in terms of knowledge, skills, and competencies. With extra emphasis on their character and professionalism (Yoon et al, 2015). Consequently, this profession is regarded as mentally demanding. Typical for this job is high fluctuation of workers a fact due to which more attention is to be paid to the procedures, these workers are participating in during their professional life. The question as which the best and most efficient way of is providing social services, or whether to carry out social work at schools have been raised in the United States of America already at the turn of the previous century. Since the very beginnings, the social work at schools (further only SSW) was aimed at bringing closer families, schools, and the community. The principal method of working involved visits to families and households in the community to improve school attendance, support education, and improving the level of social conditions. Gradually, there came to changes in the focus of the SSW as well as to turning social workers into professionals. The goals of the social work are directed towards the study of human behaviours, mental health, and mental abilities of the children. The then system was strongly affected by migration, racial disturbance with discrimination as new problems occupying the forefront.

The importance of introducing the position of a school social worker as an independent profession is documented by Shaffer (2006) completed with a list of social problems the students were facing. The author emphasizes that in many cases it was these social problems that resulted in the educational unsuccessfulness of the schoolchildren. The areas of problems have changed with time, causing social workers to be engaged not only in cases of children from poor families, but also those coming from middle-class or strata also with mental or educational problems. The forefront was taken by ideas and theories of both influential pedagogists and reputable social workers.

The current, post-modern culture is directly marked as hostile to family. In the context of social changes reflecting the transformation of relations between parents and children, attention is drawn particularly to the issues on

ethical values in terms of ideas of reverence, respect, mutual communication and understanding, which are disturbed and weakened in these days (Huang, C. Y. and Lin, C. P., 2016).

Consequently, it raises the issue to be contemplated and subsequently argued: Has not arrived the right time for the introduction of a new specialized activity taking the form of a school social work? The status of the modern society is posing a challenge to further developments in social work. In the light of a sharp rise in the socio-pathological phenomena and under the burden of statistical data illustrating cases of child's aggressiveness and criminality as well as cases put forward by the media regarding battered children and those threatened by poverty, inequality, and social segregation of families, resulting in growing social pressure raising the need take preventive action against such phenomena (Yan and Guan, 2018).

Therefore, we must consider whether it is not the school social work that represents the element of key importance in the preventive work with threatened children and families, as it is the school social worker who is the very expert within the given social environment.

2 Material and method

The overall development of the European culture and the Slovak society is bringing about and certainly will bring new problems (chicane and cyber-chicane, racial prejudices based on economic status, disinterest of a great deal of parents in schools and cooperation with them, taking addictive drugs, gambling etc.) experienced in the relations among students, students, and teachers and between families and schools.

The research sample as regards the „defining the position of the social worker in the school environment will be made up of secondary schools as organizations on which the developed theoretical and methodological principles of introducing the position of a social worker will be applied or validated. The methodology will be based mostly on the primary researched, during which the social aspects and the influences within the school environment will be determined significantly.

The expertly assigned important social aspects, influences and risks will form the basis of the concept of the efficient social worker for secondary schools. The results and conclusions of the research carried out will be generalized for

wider practical use when defining the position of a social worker within a specific school environment.

Table 1 Survey of secondary schools in the SR by types and territories

County	Secondary grammar schools	Secondary vocational schools	Schools of music (Specialized secondary schools)	Total
Bratislava county	44	57	17	118
Trnava county	22	46	14	82
Trenčín county	19	38	12	69
Nitra county	26	60	9	95
Žilina county	30	61	15	106
Banská Bystrica county	29	58	17	104
Prešov county	39	74	37	150
Košický county	36	62	25	123
Total	245	456	146	847

The data have been obtained comprehensively for the entire calendar year of 2016. The main statistical data from 229 secondary schools in Slovakia for the purpose of research have been collected from the Institute of information and prognoses of education. Contained in the data base of the institution furnished us on request were also data as the numbers of schools, classrooms, students, teachers and other premises of teaching and education arranged by the territories of Slovakia.

If we want our research to define the position of the school social worker at secondary schools (further only SS) as well as the competencies for influencing the processes and the social environment in the system of education at a reliability of 95 % and precision of estimation $\pm 0,05$, we make use of the statistical approach, which belong to the most exact methods of computing the minimum limit of respondents of the research sample.

Based on our pre-research, we defined a representative minimal scope of the sample:

$$n = \frac{z_{1-\alpha/2}^2 \times s^2}{H^2}$$

$$s = \sqrt{p \times (1 - p)}$$

$z_{1-\alpha/2}$ – required confidence interval (dependability of forecast)

usually 95% - 99% - the higher the confidence, the larger the sampling body

substituted from tables - e.g., 95%

H – admissible error span (maximal error of estimation)

usually +/- 10% - +/- 2% - the lower error is tolerated; the larger selection is to be made

substituted is e.g., $H = \pm 0,02$ (2%)

s – standard deviation

is obtained by using the formula:

p – average of mark

$H = \pm 0,05$, $p = 229/847$,

$$s = \sqrt{229/847 \cdot (1 - p)}$$

$$n = (0,5)^2 \cdot 0,3593 / (\pm 0,05)^2 = 44$$

Involved in the research were 229 secondary schools located on the territory of Slovakia. All the schools were addressed by means of an informal electronic or telephone-controlled call. Complete data have been obtained from 46 secondary schools. The minimum range of sample for the research of the concept for creating the post of a social worker in the school environment should represent a minimum of 44 secondary schools for a successful generalization of suggestions to be carried out based on research. In this case, the conditions of a qualified and relevant answers of the research sample have been fulfilled. Of the total number of teachers 89, 2 % were women and 10,8 % men. The age structure of the research sample was as follows:

- 25,2 % to 30 years of age,
- 24 % from 31 to 40 years of age,
- 19,2 % from 41 to 50 years of age,
- 31,7 % over 51 years of age.

Higher level of education of teachers under research have been acquired at the University of Comenius Bratislava (29,9 %), University of Matej Bel (29,3 %), Trnava University (13,2 %), 12,6 %, attended the University of Constantine the philosopher Nitra, 8,4 % University of Pavel Jozef Šafárik Prešov, 3 % Catholic University Ružomberku, 2,4 % Secondary School of Pedagogy, 0,6 % University of Volgograd. The research sample was made up of 158 respondents with a return on information of (83 %), whereas the number of girls and boys was equal (n=59). The respondents were between 15 as much as 18 years of age.

In cooperation with the directors of schools (principals), we have also performed collection of the data in a total of six classrooms. Administration always took place during teaching at the presence of the teacher. The questionnaire was filled in by the whole class. The students were given oral instructions as to the way of working out the papers while being ensured on the anonymous nature of the answers. Completion of the questionnaires took the period of one class. Of the total number of materials only the incomplete or improperly completed questionnaires had to be discarded.

The aim of this choice was to point out the fact that students at secondary schools are already showing symptoms of socially risky behaviour at various levels of severity. Consequently, working with them does not only consist in primary prevention. As claimed by Kabíček, CSEM and Hamanová (2014), claim that the socio-pathological utterances are apparent at as much as 60 % of adolescents.

The research determined by quantitative method was conducted using and electronic questionnaire with the help of a Google form mapping the utterances of risky behaviour. The survey also made use of the Excel spreadsheet processor. The students were also provided an instruction how the questionnaire was to be completed. The questionnaire was evaluated using a template provided to standardized questionnaires. Contained in the questionnaire of own design were the following areas of risky behaviour,

making up the notion of risky behaviour during the age of adolescence: truancy, risky way of life, risky behaviour linked to the use of internet, risky sports, betting, self-destruction, risky sexually aggressive behaviour, and petit larceny.

The answers of students could be chosen based on a five-point scale.

- 1 – never.
- 2 – rarely.
- 3 – at times.
- 4 – often.
- 5 – regularly.

The phase of data acquisition is followed by the phase of analysis and classification of information with the help of the Index of risky behaviour. Further to the validation of mutual relations among the symptoms of risky behaviour the matched Pearson Correlation Coefficient r was applied:

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}}$$

Subsequently, based on the acquired and processed theoretic-practical knowledge, the relevant socio-economic indicators were developed to be subjected to modelling by the mathematic-statistical method of DEA. The Method of DEA represents a specialized tool of modelling to assess efficiency, performance, and productivity of productional units. To assess the efficiency of the DMU a model of input-output, the so-called additive model of DEA was used under the assumption of changing the input and output parameters of the DMU. All that realized using the Frontier Analyst Professional computer program.

3 Results

The research investigation was aimed to specify as to the knowledge of the potential of a social pedagogue for solving problems related to the syndrome of risky behaviour during adolescence with secondary school children. – The partial goals of the mixed design were:

1. Mapping the seriousness - of the risky behaviour syndromes within the set of secondary school students and verify the current occurrence of the symptom of risky behaviour by way of a questionnaire –based survey.
2. Mapping the level of proficiency at skills to institute an efficient position of a school social worker based on informal interviews conducted with directors (principals), special-pedagogues, secondary school teachers in Slovakia.

Computed in Graf 1 is the risk index of selected symptoms of risky behaviour, the value of which is 1,71 and the rate of risk increases proportionately to the occurrence of the symptoms among the respondents under research. The table reveals that the highest risk index is representing risky behaviour related to the internet. Next come the risky way of life, sexual behaviour, truancy, risky sports, petit larceny, aggressive behaviour, betting, and self-maiming.

Graph 1 Symptoms of risky behavior with students by gender (%)



Illustrated in Graf 1 is the occurrence of behaviour within the sample of the respondents. Boys are apt to perpetrate risky behaviour to a higher extent than girls. Risky lifestyle, self-destruction and higher-level sexual experience are the priorities of girls.

Table 2 is illustrating the results of the correlation among the symptoms of risky behaviour with the respondents of the research sample. Computation was made using the Microsoft Excel 2010 program. Statistically significant relations have been found with and between the following symptoms of risky behaviour: sexually risky behaviour and truancy ($r = 0,43^{**}$); petit larceny

and truancy ($r = 0,35^{**}$), sexually risky behaviour ($r = 0,28^{**}$), risky behaviour on the internet ($r = 0,38^{**}$), betting ($r = 0,20^{**}$); aggressive behaviour and truancy ($r = 0,30^{**}$), sexually risky behaviour ($r = 0,29^{**}$), risky behaviour on the internet ($r = 0,36^{**}$), petit larceny ($r = 0,47^{**}$); index of risky behaviour and truancy ($r = 0,33^{**}$), sexually risky behaviour ($r = 0,56^{**}$), risky behaviour and the internet ($r = 0,29^{**}$), petit larceny ($r = 0,44^{**}$), self-maiming ($r = 0,40^{**}$), aggressive behaviour ($r = 0,39^{**}$).

Table 2 Relation between risky behaviour and the respondents

SPJ	Truancy	Sexual experience	Tool of comm. - internet	Betting	Crimin.	Self-maiming	Aggressive behaviour	Index
Truancy	1							
Sexual experience	0,43**	1						
Tool of comm. - internet	0,15	0,10	1					
Betting	0,13	0,04	0,22*	1				
Crimin.	0,35**	0,28**	0,38*	0,20*	1			
Self-destruction	-0,02	0,04	-0,08	0,03	0,09	1		
Aggressive Behaviour	0,30**	0,29**	0,36*	0,03	0,47*	0,07	1	
Index	0,33**	0,56**	0,29*	0,08	0,44*	0,40**	0,39**	1

Legend:

* Correlation at the level of significance 0,05.

** correlation at the level of significance 0,01.

Statistically most important is the relation between the Index of risky behaviour and symptom of sexually risky behaviour ($r = 0,56^{**}$), followed by the relation between aggressive behaviour and petit larceny ($r = 0,47^{**}$), further the relation between the Index and petit larceny ($r = 0,44^{**}$). The results obtained are certifying the current occurrence of those individual

symptoms of risky behaviour, which involve the syndrome of risky behaviour in adolescence.

The current level of development as regards professional competencies were to be evaluated by the respondents of the research sample at a scale from 1 to 6, whereas 1 was to express a very low level of development, number 2 indicating low level, number 3 rather low level of development, while number 4 a more developed level, number 5 a highly developed and number 6 a very high level of development. As presented in the table, the individual professional competencies were assessed by the respondents of the research sample, with averages in assessments oscillating within the interval of 3,13 as much as 4,56. The respondents awarded the highest level of development in professional competencies to the „Capability of professional growth“, which in total obtained the average value of 4,07, which represents a fairly higher level of development.

Table 3 Level of development in the competencies of social workers in the school environment

Competencies of a social pedagogue	Average
1. Capability of developing efficient communication	3,86
2. Capability of analysing and planning the working process	3,54
3. Supporting and helping towards independence to ensure human dignity	3,67
4. Capability of providing and realizing the relevant services	3,48
5. Capability of contributing to the work efforts of the organization	3,80
6. Capability of growing professionally	4,07

Higher levels of development have also been achieved at other criteria regarding the competencies covering the capabilities of the capability of professional growth. A generally higher level of development ($p = 3,86$) has also been recorded at the Capability of developing efficient communication. The viewpoint of the criterion of contributing to the teamwork represents, based on the values, a similarly well-developed competence earning the total average value of 3,80. In the area of „Supporting and helping towards independence to ensure human dignity“, we have identified criteria with higher levels, stage of development, which in connection mostly to „Providing support to the client's skills and s and capabilities“. The

competence of „Capability to analysing and planning of the working process“ has earned a predominantly lower value. The result can be attributed to the fact that development of further criteria of professional competencies can surely be achieved at direct contacts with individuals. On the other hand, we can arrive at a negative statement for the respondents assigning lower values to criteria, which could be of good use in their development and preparation.

The conditions within the preparation for the development of professional competence criteria could be improved mostly by professional practical experience, which currently in the SR is falling behind because of inadequate legislation, organizational and financial situation, all of them barriers to the preparation of future social workers for schools. It can be declared that a school social worker has more time available as a pedagogue or other employee of the school and is regarded indispensable for the student suffering from problems. This issue is actual more than ever and is unavoidable. Consequently, it deserves more research to add to the pool of arguments in favour of the defending this position within the system of education.

3.1 Measuring the efficiency of selected competencies of school social worker/s

Based on the data obtained, we have identified the efficiency limits between the competencies for the purpose of establishing the position of a school social worker at secondary schools. Selecting the individual weights was dependent on the evaluation scores obtained for the competencies for the position. A great advantage to the DEA method consists in its ability to integrate the social factors of the external environment formulated either as inputs or outputs. Typical applications in this regard are comparisons and evaluation of the efficiencies at systems such as schools, hospitals, agricultural companies, banks, research institutes, companies active in transportation and various public services, i. e. mostly system featuring heterogenous and poorly aggregable inputs and outputs.

Secondary schools can be regarded as homogenous productional units- with outputs in education, inputs involving adequate equipment and human resources. The differences among vocational secondary schools, secondary grammar schools and Music schools result only from the different areas of engagement. The individual competencies reflect the input and output

parameters of the DEA model. With respect to the nature of the organization under assessment, efficiency of the productional units was computed based on a selected input-output oriented (additive) model, obtaining in via the model 6 model situation of efficiency analysis presented in Table 4 that follow:

Table 4 Efficiency of criteria inputs and outputs

Overall efficiency of the criterion “Capability of developing efficient communication” (76 %)			
Inputs	Efficiency	Outputs	Efficiency
Lack of time and opportunity for assessing client’s ideas	-0,56	Adaptation in terms of adjusting the way of communication to the age of the client and his/her social conditions	0,63
Poor motivation for overcoming barriers to achieving clients ’goals and learning from one’s own faults.	-0,75	Maintaining and developing relations and open communication with the client and his or her environment establish optimal feedback.	0,83
Paying no respect to clients ‘conditions	-0,78		
Lack of maintaining relation with the client and its environment to establish an optimal feed back	-0,96		
Failing to adapt to the conditions of communication between the individual, organization, and the wider community	-0,81		
Overall efficiency of the criterion “Capability of analysing and planning the working process” (48 %)			
Inputs	Efficiency	Outputs	Efficiency
Inability of taking controller of the processes and procedures documented	-0,34	Leading clients to understanding the consequences of various decisions	0,67
Failing to focus on risk factors and define their limits	-0,47	Identifying goals, resources, barrier and suggesting solutions for potential improvement	0,29
Inability of finding one’s way in the legislation related to the social and	-0,82	Collecting and analysing information from various sources	0,25
		In cooperation with the clients and	0,53

organizational conditions		their environments, thinking over the potentials for prevention and solution to the arising problems and their effects.	
Overall efficiency of the criterion “Supporting and helping towards self-sufficiency” (0,67)			
Inputs	Efficiency	Outputs	Efficiency
Inability of identifying the clients ‘strengths	-0,64	Capability of offering emotional support	0,81
Poor support to skills and client’s capabilities	-0,72	Taking clients ‘interest into consideration and assuming responsibility for potential risks	0,67
Rising trend in discriminating and segregation of minorities	-0,78	Capability of explaining people their rights and potentials in applying them	0,45
		Understanding clients and exercising supervision over their social behaviour	0,63
Overall efficiency of the criterion “Capability of providing and realizing relevant services” (0,68)			
Inputs	Efficiency	Outputs	Efficiency
Failing to provide services in line with the agreed working procedure	-0,52	Aiding in handling clients ‘legal cases, dangerous situation and stress	0,53
Unsuitable conditions for function of the client following the completion of services	-0,71	In cooperation with the clients, exercising regular monitoring of the changing situation and efficiency of the procedures in cooperation with the clients	0,78
Failing to identify the potentials and methods of providing services and taking measures	-0,86	Organizing assistance and providing services from various sources	0,75
Participation in the procedures that improve social level of the individuals	-0,64	Resisting behaviour, which may turn into factors of risk and threat to the individual	0,65
Overall efficiency of the criterion “Capability of contributing to the work/efforts of the organization” (0,57)			
Inputs	Efficiency	Outputs	Efficiency
Ability to effectively communicate and cooperate with the co-workers	-0,65	Accepting clients ‘and co-workers’ ideas regarding one’s own work	0,73
Failing to identify one’s own position and capability for auto-supervision when involved in teamwork	-0,44	Taking part in the critical assessment of work towards improving its culture	0,48

Failing to act in compliance with the clients’ rights and the ethics of social work	-0,61	Identification and effective use of the available sources and understanding the priorities involved	0,52
		Understanding the structure of company organization, its goals and reflecting/respecting its rules and modes of operation	0,54
Overall efficiency of the criterion “Capability of growing professionally” (0,59)			
Inputs	Efficiency	Outputs	Efficiency
Identify one’s own deficiencies and barriers as well as those of the working-team with the purpose of overcoming them	-0,51	Acquiring further skills and knowledge related to the social work	0,43
Poor organization of work in the light of the defined goals to be achieved	-0,74	Making efficient use of the contacts acquired, discussing, and exchanging ideas and experiences at workshops and educational activities	0,47
Inability of handling stressful situations	-0,76	Identifying one’s own deficiencies and barriers and those of the work-team with the purpose of overcoming them	0,68
		Perform assessment and accept responsibility for the risks involved in making decisions within the work-team	0,52
Difficult relations at the place of work	0,53	Preforming continuous search of new opportunities and making use of the latest trends to find new solutions bringing about positive changes	0,66
		Seeking answers and finding inter-relations among the potential solutions	0,63

The reasoning behind the instituting this position at schools, given by the respondents agreeing with the worthiness of a social school worker at secondary schools, is based on the lack of having a comprehensive view on the students, which bears on the already indicated lack of opportunities for mapping and identifying activities focused on socio-pathological phenomena, i.e., searching for potential threats before real problems strike the eye. However, maintaining relations between the family and school to establish an optimal feed-back (weight for improvement 0,96) are the pre-conditions of the process.

Low level of efficiency as regards cooperation on the part of the families of children is the most frequently cited reason for instituting the position of a school social worker. The present position of the Slovak schools in terms of authority raises worries on the part of the parents, which result in the lack of open communication with the school (weight for improvement 0,83), making cooperating even more difficult. Consequently, it is more appropriate that the main activities of the school social workers be realized in the form of consultancy for both the students and their parents also having them involved in the work with the children at school.

Based on the results of the criterion reflecting the capability of finding one's way and planning working procedures at secondary schools, the DEA indicated the lack of such a function at Slovak secondary schools (efficiency of the competence 48 %). As shown by the DEA modelling for competence in orienting oneself and planning the work procedures, the overall efficiency has a value lower than 1 or 100 %, a fact is to be regarded as the sign of deficiency, or lower efficiency of the unit, dully deserving special attention in the light of link with the analysed issue.

Within the framework of social consultancy and social prevention, a school social worker could also provide services of crisis assistance as well as socio-activation services for families having children. Of the concrete activities involved in the range of services, his or her responsibilities could entail mediating contacts with the social environment, aiding in the application of law, putting through justified interests, acquiring personal effects, education and activation, social therapy, training of skills for caring for oneself, self-sufficiency etc. leading to integration into the society.

Based on the DEA model, we came to realize that the mandate of the school social worker, within the framework of the analysis performed on the indicators of supporting self-sufficiency to socio-legal protection of children, could also be a contribution to higher efficiency of this profession.

Competence outlined by the DEA model is recording how a social school worker is managing its competence, on condition that he or she is meeting the criteria set for a well-functioning system of services, and what else is involved in it. In case of inefficient units, the DEA analysis has suggested reduction of inputs followed by the expansion of outputs for them to achieve efficiency.

The competence is representing a wider view on the issue of social work and the knowledge of the entire network of services. Quite often, social workers have no knowledge of the methods applied in their own organization, as they are failing to follow trends and the newly developing methods (Capability of knowing potentials and methods of providing services and interventions (weight for improvement -0,86). The measure of difficulty depends on the rate of progress experienced in the given area, something the social worker is simply unable to keep an eye on. Of also great importance is to point out the insufficiency of the system of education due to the differences based on generation, territories, localities etc. To meet the criteria, the SSW must be widely knowledgeable of professional matters regarding the models and methods of social work, their history and development, organizational form not only in our country but also abroad, the advantages and disadvantages for various groups of people and distinctive areas. Further, he or she must have practical knowledge as to what services are available in the region, outside the SR and those, which do not exist so far.

The social worker is regarded as a responsible member of the organization contributing to the improvement of their mutual work, evaluation of the efficiency of the services provided for the clients while striving for making efficient use of all the resources available. The main goal of this competence is cooperation between the SSW and the co-workers and colleagues within the company. The competence with an efficiency value of 57 % has so far not been regarded as integral part of professional competencies of the social worker. Consequently, applying the criteria in practice is rather infrequent and mostly conflicts with the company culture established in the organization. Meeting the following criteria can be regarded as a sensitive indicator of culture governing the branch of educational system. The criterion of "Understanding the structure of the organization, its goals reflecting the rules and modes of operation "(change towards improvement with a weight of 0,54) is considered as a matter of course, whereas the complexity of putting it into practice depends on the company culture. Meeting that criterion is helpful in overall orientation and cooperation within the organization and cultivating the sense of safeness on the part of the employees (and students, as well).

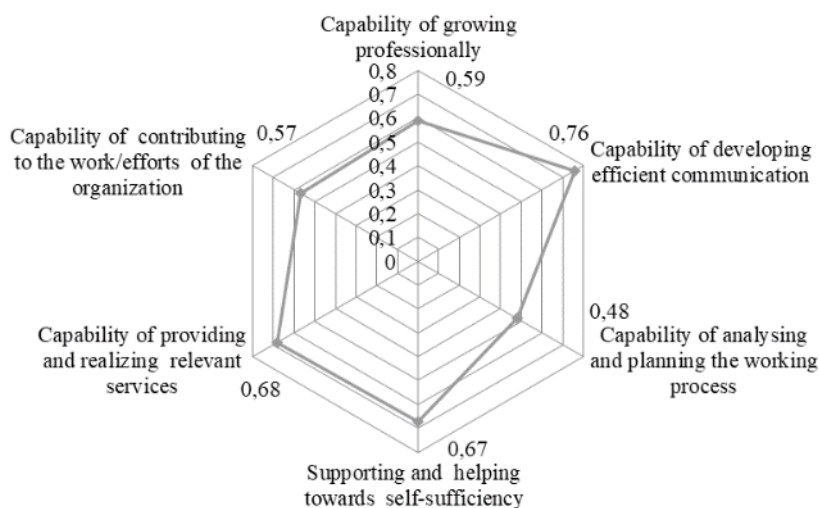
The competence of professional growth is representing the general qualities of a sound professional and employee, as it is perceived throughout the

highly developed western countries. It involves the capability of life-long education, decisiveness, openness to cooperation with others, engagement in the branch, being able of organizing one's own work. In case of a school social service worker the list is topped by some extra, personal criteria. Based on the results achieved, he or she should be making qualified decisions, provide consultancy and be in control of his responsibilities and personal and professional growth. The social worker is also capable of achieving the goals defined, cooperating, in the given area of responsibilities, thereby contributing to the development of social work and positive changes in this branch.

3.2. Solutions of optimization proposed for the introduction of the post of a social worker

In most cases, the proposal to optimize solution for inefficient criteria of the individual competencies of school social worker and defining his or her place at secondary schools follows from a stricter reduction of inputs and expansion of outputs to achieve maximal efficiency of the results obtained by way of the additively oriented DEA model.

Graph 2 Radar graph of competencies for a school social worker



The results of the mathematical model cannot be taken definitive, even if they lead towards maximal efficiency in all the evaluated units, as proven above

(Table 4). For the inputs of inefficient parameters to be reduced as required by the DEA analysis to achieve maximal efficiency. There exist limitations taking the form of requirements of real feasibility, recommendations, and legislative requirements for preserving certain level of some of the inputs. Any attempt towards a systematic institution of the school social pedagogue should be accompanied by an information campaign focused on the management of schools and school teams.

A material should be developed in which the profession of the school social pedagogue be presented in via its concrete contributions for the concrete school along with examples of successful handling problematic situations and aspects of life at the school, so familiar to both the teachers and the managements. At the adaptation courses of school's presentations of activities led by school social pedagogue can also be demonstrated. Within the framework of the methodology, a special methodology is to be developed for the social pedagogue and another methodology for the selection of school where the position is to be installed. The school should develop a basic document formulating its expectations and what organizational conditions it can form for functioning of the social pedagogue. Further, a methodology of the selection process for the position of social pedagogue. It would also be necessary to develop a training module / course for the preparation of the candidates, who are not qualified in the trade of social pedagogy.

If the school social worker is primarily viewed as a tool of intervention, particularly into the branch of secondary school system, there is a great need for assigning him or her more power with due regard to the inclusive nature of the profession performed under risky conditions of work. If a long-term plan is developed to institute the position of the school's social worker across-the- board, as a systematic element within the entire system of regional education, the instituted position makes sense, then it is up to the schools to make their decision. Financing a systematic introduction of the SSW also calls for systematic and continuous efforts in this regard. Activities of the social pedagogue at school must make sense, and on a long-term basis. The position should not be financed by way of short-term endowment funds or projects. On winning the entitlement, and having the position proven, the school should be able to apply on a long-term basis and continuously. Otherwise, it will be impossible to find out to what extent the position has

answered the purpose. It also means that if the position is to be extended, certain financial means must be simultaneously added.

We recommend that secondary schools introduce the position of SSW as part of the major line of education. If only the position is found active per schools, he or she should be in full-time employment. In case e working at two schools simultaneously, he or she could be employed on a part-time or external basis, while probably employed at the local pedagogic and psychologic advisory department. Beginners in the sphere of social pedagogy should be mentored by their more experienced colleagues. All SSWs should meet on a regular basis at local and regional multilateral workshops (once per month for at least 3 hours) and should dispose of an external supervision (every 3 months for 3 hours as a minimum).

We strongly recommend that the institution of the position be plane and realized on a real and methodical basis, and financing of this position be arranged for a long-term with sustainability. It is to mean that if the position is to be spread all over the schools, it must be backed by adequate growth in the finance for remuneration. Non-systematic or short-term financing of the SSW may lead to losing credibility of schools regarding the position, thereby destroying the intent of schools for internal reforms and changes for good, the institution of introduction of the position can offer.

4 Conclusion

Development of a competency model of creating the position of a school social pedagogue at secondary schools is preceded by identification of the competencies, which is in line with the principle of doing the same things in different ways, and here it is appropriate that the competence model is not following the way of establishing standards, but the one-off managing diversity an performance. It is about concrete combination of knowledge, skills and further personal characteristics that are necessary for the tasks of the organization to be fulfilled efficiently. The competence model can be used in various areas of human resource management e.g., evaluation of the employee when selecting for new positions, company reorganization, staffing the manpower, planning employee careers or the general development of the workforce.

Implementation of the knowledge from the area of social work into the system of education represents a new way of viewing the role of social worker within the branch of education. Based on evaluating the data obtained by way of survey at the selected specimen of schools, we can clearly define the causes or barriers that hinder the efficiency of developing social work at schools. The results of this work can also serve as a basis for case studies for education. Further, they can be used for the preparation of seminar topics, demonstrations of applying research methods etc.

The specific competence model developed for defining the position of the SSW is based on the distribution of competencies of authors Belza a Siegrist (2001), making use of the status in the problem area both at in our country and abroad. Unlike the authors, the model differs in developing competencies. As for their contents, they refer to the same idea. Competencies can be developed and trained. Every individual has certain competencies at various levels between "highly developed" and "poorly developed". To a certain level, were able to influence the skills, motives, values, and the unintentional behaviour. Among the easiest to develop are knowledge, information, factual and professional learning, procedures of problem solving and mutual communication. Consequently, contribution can also result from the development of competencies based on acquired knowledge applying the non-parametrical model of DEA that we have dealt with so much.

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Digitization of Polish public universities - selected issues

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Abstract. The rapidly developing digital services market is not only the domain of commercial entities, but also an area where computerization of public entities is happening, including the progressing digitization of Polish public universities. Trust services and electronic identification mechanisms are issues that Polish public universities meet both in the context of performing their basic tasks, which include research and education, and also in all other areas of their operations. The subject of this work is to present selected issues in the scope of digitization processes and their impact on the functioning of Polish public universities, in particular in the area of flow and delivery of correspondence, as well as the possibility of case processing using the means of electronic authentication and identification. The considerations and conclusions presented in this work are based on the Polish legal solutions as well as practical experience gathered during the implementation of the pertinent mechanisms at the Krakow University of Economics (KUE).

Keywords: public university, digitization, electronic delivery, authentication and electronic identification.

JEL Classification: K

1 Introduction

The developing market of digital services coupled with the progressive computerization process of the operations of both public and non-public entities resulted in the need to standardize the rules for the functioning of the legal space in this domain. The unification of the rules for the provision of trust services and electronic identification means within the European Union countries was reflected in the provisions of the eIDAS Regulation (2014). The enactment of the above-mentioned regulation was one of the key activities for the implementation of a single European digital space (Dragan, 2016). The legal framework adopted in the eIDAS Regulation (2014) became the basis for launching legislative processes aimed at adapting the solutions currently in force in Poland to the European Union legal order, and ensuring the uniformity of the system guiding the functioning of the digital services

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market. These processes have a direct impact on the functioning of Polish public universities. Trust services and electronic identification means are matters that public universities face both when performing their basic tasks, but also in other areas of their activities. They apply to a public university as an entity implementing research and education, but also as an entity performing the function of a public administration body or being a party to concluded agreements.

This work will discuss selected issues related to the digitization of a Polish public university, including as a subject of civil law activities, as the sender and the addressee of correspondence, in managing its internal and external documentation, participating in activities covered by the administrative procedure, and carrying out operations related to handling student affairs.

2 Digital operations in the sphere of civil law

A public university, like any other legal entity, performs legal acts by submitting declarations of will in a specific form. The university is an entity with legal personality, i.e. operating through its bodies, in the manner provided for in the Act on Higher Education (2018) and in its By-laws. Submitting declarations of will – as part of the legal actions taken – is an everyday operation related to the functioning of the university and the implementation of its tasks. In terms of representing or managing the university, legal actions are taken on its behalf by the university's Rector. Declarations of will are also submitted by other bodies within the scope of their competences, by persons holding managerial positions or by other persons operating within the organizational structure of the university. These activities are either unilateral declarations of will (e.g. granting powers of attorney) or multilateral activities (e.g. concluding contracts).

In the sphere governed by civil law, a person (an entity) can declare of express their will by any behaviour of that entity that sufficiently discloses this will, including its disclosure in electronic form (Civil Code, 1964) (Article 60). Civil law entities very often declare their will in electronic form and send a message in this form by means of remote communication, in particular by e-mail, SMS, MMS, or via websites (Maciejewska-Szałas, 2022). However, as emphasized by Maciejewska-Szałas (2022), the legislator introduced exceptions to the principle of the freedom of the form for a

declaration of will, stipulating in numerous provisions (...) the obligation to perform certain types of legal acts in a particular and specific way (e.g. a notarial deed). An action that has not been performed in the format prescribed by law may be considered invalid. In the event of a dispute, the form of legal acts is also important for evidentiary purposes, i.e. the possibility of taking evidence from the testimony of a witness or hearing the parties on the occasion of its performance.

Looking at this issue in the context of the functioning of a public university, we see that the vast majority of declarations of will addressed to external entities are submitted in writing, and this is primarily due to the security of this form in terms of evidence. The progressing digitization process means that the ordinary written form, for the preservation of which it is sufficient to submit a handwritten signature on a document containing the declaration of will, can be replaced by an electronic form. A declaration of will submitted in electronic form has been equated with a declaration of will submitted in writing, however, in order to maintain the electronic form of a legal transaction, it is necessary to submit a declaration of will in electronic form, and affix it with a qualified electronic signature (Civil Code, 1964) (Article 781). Not every electronic signature can be recognized as qualified. For it to be recognized as such, the electronic signature must be submitted using a qualified device, and must be based on a qualified certificate issued by a qualified trust service provider (Regulation eIDAS, 2014) (Act on Trust Services and Electronic Identification, 2016). In cases where such signature is lacking, the declaration of will that had been made in electronic form may be construed as submitted in the documentary form as long as its author can be identified (...) or possibly it may be regarded as a technical means of manifesting the will (...) (Janas, 2018).

When both parties sign the contract in an electronic form, i.e. with a qualified electronic signature, this is equivalent to their signing the contract in writing (with a handwritten signature). The contract may be concluded with the use of a qualified electronic signature also when only one party has such signature, and the other party submits a declaration of will in writing. The entire contract concluded in this way is documented by an electronic file bearing a qualified electronic signature of one of the parties together with a paper copy signed by the other party. It is also possible to conclude a contract in such a way that one of the parties submits a declaration of will in an

electronic form, and the other party in a documentary form. To maintain the documentary form of a legal transaction, it is sufficient to submit a declaration of will in the form of a document (i.e. information carrier, which enables the reading of its content) in a way that allows the identification of the person submitting the declaration. (Civil Code, 1964) (Articles 772, 773). Declarations of will made in documentary form can include messages sent via e-mail, scans of documents, or documents signed with an unqualified electronic signature (e.g. with a trusted profile). However, this form of concluding the contract is not considered to have a written form.

Using a qualified electronic signature is the preferred method at KUE when submitting declarations of will or concluding contracts. This type of signature is the most convenient form of action in the civil law sphere, making it possible to save time related to the circulation of documents in a traditional form, as well as being safe and admissible as evidence in court proceedings. It is also valid in all European Union countries, which is important in the activities of KUE on an international scale.

3 Electronic registered delivery

One of the most important legal acts regulating the functioning of public sector bodies – including public universities – in the digital legal space is the Act on electronic delivery services (Electronic Registered Delivery Act, 2018). Electronic Registered Delivery Act (2018) imposed a requirement for the public entity to possess an address for electronic delivery, entered in the database of electronic addresses and linked to the public service of electronic registered delivery (Article 8). The deadline for implementing technical solutions enabling public universities to deliver and receive correspondence universally in the manner indicated above has not yet been indicated – it will be determined by the Minister responsible for computerization – as no later than January 1, 2024 (Electronic Registered Delivery Act, 2018) (Article 155 section 5 and sections 10-12).

Delivery of correspondence by electronic means will be possible only if the public university has an address for electronic delivery entered in the database of electronic addresses, allowing for an unambiguous identification of the sender or the addressee of the transmitted data (Electronic Registered Delivery Act, 2018) (Article 2 section 1). Delivery will be made via an

electronic delivery inbox, i.e. a tool that facilitates sending, receiving and storing data as part of the public electronic registered delivery service, as well as the hybrid public service (Electronic Registered Delivery Act, 2018) (Article 2 section 9). Addresses for electronic delivery will be collected in the database, which is a public record kept by the Minister responsible for computerization.

The subject of electronic delivery will be an electronic document, the legal definition of which is contained in the provisions of the eIDAS Regulation (2014) (Article 3 point 35). The concept of an electronic document has broad meaning (Wróbel, 2022; Biskup and Ganczar, 2008). Electronic document means any content stored in electronic format, in particular text or audio, visual or audio-visual recording.

Correspondence – requiring registration of posting or confirmation of receipt – will be delivered by the university using the public service of registered electronic delivery to the address for electronic delivery entered in the database of electronic addresses. If the address for electronic delivery of a non-public entity is not entered in the database of electronic addresses, then any correspondence should be sent to the address for electronic delivery from which the non-public entity sent their mail (Electronic Registered Delivery Act, 2018) (Article 4). The address in question should be understood as an electronic address that enables the sender or addressee to be unequivocally identified, i.e. the electronic address of a non-public entity associated with a qualified electronic registered delivery service provided by a qualified trust service provider from which the entity sent correspondence (Wilbrandt-Gotowicz, 2021). If it is not possible to deliver the mail to the address for electronic delivery, the kind of correspondence which requires confirmation of posting or receipt will be delivered by using a public hybrid service, or otherwise, resulting from specific regulations, for instance, delivered in person by an employee (Electronic Registered Delivery Act, 2018) (Article 5, Article 6).

The public service of registered electronic delivery is provided by the designated operator, in accordance with the standards required for trust services and electronic identification (Act on Trust Services and Electronic Identification, 2016) (Article 26a) and at affordable prices. The designated operator ensures, in particular, the identification of the sender and the

addressee as well as secure sending and receiving of data with an advanced electronic seal in a way that excludes the possibility of undetectable data change. As part of the service of registered electronic delivery, the designated operator is obliged to issue proofs of sending and proofs of receipt of mail correspondence (Electronic Registered Delivery Act, 2018) (Article 38, Article 41). The designated operator is also required to provide a hybrid public service. The latter consists in converting an electronic document sent from an electronic delivery address into a letter item in order to deliver correspondence to the addressee. The conversion is carried out in an automated manner, ensuring the protection of postal secrecy at every stage of the service. (Electronic Registered Delivery Act, 2018) (Article 45, Article 46). Pursuant to the Electronic Registered Delivery Act (2018) (Article 149 section 1), Poczta Polska S.A. [Polish national postal service] will act as the designated operator until 31 December 2025.

A qualified service of registered electronic delivery, available to non-public entities, may also be used for correspondence with the university (Electronic Registered Delivery Act, 2018) (Article 2 section 3). It is an optional service in relation to the public registered delivery service, implemented on the basis of a detailed standard specified by the Minister responsible for computerization (Electronic Registered Delivery Act, 2018) (Article 134), consisting in the provision of addresses for electronic delivery by qualified trust service providers. Suppliers will provide non-public entities with “qualified” addresses for electronic delivery, which may be entered in the database of electronic addresses only upon request (Justification of the draft Electronic Registered Delivery Act, 2018). A qualified trust service provider may be an entity that has passed an audit with the compliance assessment of the services provided within the eIDAS Regulation (2014), and has been entered into the records of trust service providers.

Establishing an address for electronic delivery requires the institution to submit an appropriate application to the Minister responsible for computerization, bearing a qualified electronic seal or a qualified electronic signature of the university. The application is submitted using the online service provided by the Minister responsible for computerization. (Electronic Registered Delivery Act, 2018) (Article 12, Article 15 section 1).

Before submitting an application for entry in the database of electronic addresses, the university must designate a person to act as an administrator of the electronic delivery inbox. Appointment of an administrator by the university is obligatory (Electronic Registered Delivery Act, 2018), (Article 19 section 1). Administrator is entitled to activate an electronic delivery address. Effective activation makes it possible to proceed with the implementation of activities belonging to the basic duties of the administrator, i.e. management of the electronic delivery inbox (Electronic Registered Delivery Act, 2018) (Article 19 section 3 and section 5).

Managing the electronic delivery inbox includes, in particular, performing the following operations: sending and receiving correspondence, managing correspondence, including the introduction of rules for defining the transfer of correspondence to other ICT systems in an automatic manner and configuring the inbox (Electronic Registered Delivery Act, 2018) (Article 19 section 6). The administrator of the inbox therefore plays a key role in the process of its proper and efficient functioning. Proper handling of the registered delivery inbox, along with the implementation of university-specific rules for transferring correspondence to other ICT systems (see point 4 below), are important not only to ensuring an efficient internal correspondence flow, but also due to the timeliness of handled cases and not remaining idle towards external entities.

4 Electronic documentation management and archiving

The mere activation of a registered delivery inbox may turn out to be insufficient for the efficient functioning of the electronic delivery system at the university. For this process to be comprehensive, electronic documentation management systems are necessary. As indicated in the National Archives Act (1983) (Article 6), universities are required to provide adequate records, storage, and protection against damage, destruction or loss of the documentation created, sent and submitted to them, in a manner that reflects the course of handling and settling cases. The above tasks may be performed within the system of electronic delivery, which is a system of performing office operations, documenting the course of settling and resolving cases, collecting and creating documentation in electronic format.

The performance of obligations related to the securing of documentation accumulated in the course of the university's operation is regulated in legal acts of an internal nature, collectively referred as office and filing instructions and archival norms (Konstankiewicz, 2016). The content of these acts is determined in agreement with the General Director of the State Archives. The implementation of an electronic documentation management system must therefore be preceded by changes to the applicable office and filing instructions and archival standards, by adopting the possibility of fulfilling archival obligations with the use of an electronic system and defining the scope of its implementation. Universities with a traditional filing system (all documents must have a paper version and this is the basic method of archiving), can use two ways of introducing an electronic system: either gradual, consisting in retaining the traditional system and introducing the exceptions, within which the entire procedure of settling the case and its archiving will be carried out in an electronic way, or transitioning to an electronic archiving system, with the exceptions that will continue to function in the traditional way. The adoption of the electronic system means that there is no possibility of "going back" to archiving in the traditional system. An electronic documentation management system can be integrated with the electronic delivery system. The integration will offer full advantages of the electronic delivery service, while increasing the functionality of electronic documentation management systems.

KUE decided to abandon the traditional archiving system in favour of archiving in an electronic system. Activities related to the initiation of the procedure of reconciliation of office and archival norms with the General Director of the State Archives, along with the determination of exceptions, which shall be left in the traditional archiving system, are underway. The internal circulation of documents at the university functions on the basis of the Temporary Electronic Circulation of Documents software, which is generated on an on-going basis, primarily dedicated to handling research projects and grant procedures. At the same time, the KUE is getting ready to implement a comprehensive electronic documentation management system, which will allow for methodical dealing with matters in electronic format as well as for their digital archiving, and will also constitute a basis for integrating the ICT systems presently functioning at the university.

5 Digital operations in the administrative procedure

In specific cases, the regulations governing the functioning of higher education place a public university under the obligation to apply, the administrative procedure regulated by the provisions of the Code of Administrative Procedure (1960). Administrative decisions are issued by the university's Rector or by other entities authorized to do so (e.g. recruitment committee, scholarship committee). Decisions are issued in particular in student matters, e.g. refusal to admit to studies, granting and refusing to grant financial assistance, striking off the list of students; in promotion procedures; as part of education at the doctoral school such as refusal to admit to a doctoral school, or striking off the list of PhD students (Act on Higher Education, 2018) (Article 72 section 3, Article 86 section 2, Article 108 section 3, Article 178 section 1, Article 200 section 5, Article 203 section 3).

As indicated in the Code of Administrative Procedure (1960) (Article 39, Article 63), electronic deliveries made by the university as part of the administrative procedure, as well as submitting applications to the university as a public administration body, in principle will be based on the regulations set out in the Electronic Registered Delivery Act (2018). This will take place from the moment the university obtains an address for electronic delivery, i.e. by the date indicated by the Minister responsible for computerization (see point 3 above) at the latest. Until then, correspondence in administrative proceedings will be delivered to non-public entities in electronic form on the basis of the existing regulations, i.e. via the electronic inbox of the university (ePUAP) (Act on the Computerization of Entities Performing Public Tasks, 2005) (Electronic Registered Delivery Act, 2018) (Article 158). An important addition to the rules for electronic delivery under the administrative procedure is the reservation that this procedure will also allow for delivery to an account in the university authorities' IT system (Article 39, Article 63). As emphasized by Sibiga (2022), this solution is a breach in the purposes of the registered electronic delivery reform because the legislator has not defined the concept of an account, therefore entities may use any IT solution based on individual user accounts in ICT systems that support the proceedings (...).

Code of Administrative Procedure (1960) provides for a general rule of settling matters in writing, recorded in either paper format or electronic format (Article 14). Letters in paper format bear a handwritten signature.

Letters recorded in electronic format can be affixed with a qualified electronic signature, a trusted signature or a personal signature, or a qualified electronic seal of a public administration body with an indication in the content of the letter of the person affixing the letter with the seal. Letters to the authorities may also be made in either hard copy or electronic copy, and bear signatures and seals according to the principles stated above. Therefore, the administrative procedure, apart from a qualified electronic signature, allows the use of such means of identification as a trusted signature, personal signature, or qualified electronic seal. Trusted signature is an electronic signature, the authenticity and integrity of which are ensured by using the electronic seal of the Minister responsible for computerization. A personal signature is an advanced electronic signature verified by a certificate, i.e. a digital certificate that assigns the data used to validate the personal signature to the holder of the specific ID card, thus confirming the data of that holder. The legal definition of an electronic seal is included in the eIDAS Regulation (2014) (Article 3 point 12), indicating that these are electronic data added to or logically related to other electronic data in order to ensure the authenticity of the origin and integrity of the related data. The eIDAS Regulation (2014) distinguishes two types of electronic seal. The first is an advanced electronic seal, i.e. an electronic seal that meets the following requirements: it is uniquely assigned to the creator of the seal, allows the identification of the creator of the seal, is created using electronic seal creation data that the creator of the seal can use, with a high degree of certainty under their control, to create an electronic seal and is linked to the data, to which it relates, in such a way that any subsequent change of the data is recognizable. The second is a qualified electronic seal, i.e. an advanced electronic seal that has been created by a qualified electronic seal creation device and which is based on a qualified certificate for electronic seal.

6 Digitized student services

The digitization of public universities in the field related to education is manifested, inter alia, in the universities' using IT systems related to student recruitment, systems for managing the course of study (e.g. the USOS system operated by KUE), maintaining documentation of the course of studies in the form of an "electronic file", issuing digital student ID cards, the possibility of verifying learning outcomes and conducting diploma exams using electronic

means of communication, and documenting them in the digital format. Digital student service also includes systems that allow the student to settle cases resulting from his or her status as a person studying at the university in the most computerized way possible, not requiring the student's physical presence. These aims are achieved by student service centres, which facilitate remote, comprehensive and effective settlement of the cases. For this purpose, at the KUE, intensive work continues, aimed at enabling students to settle their cases using a dedicated website on the Internet and an ICT system, and to minimize the number of cases requiring direct contact. For this purpose, a handbook of procedures describing individual operations carried out in the organizational units of the university is developed, and case charts are prepared, which shall allow the student to initiate the appropriate procedure through the ICT system, without the need to report at the university in person, and on the part of the university – to settle the case remotely.

7 Conclusions

Only selected issues related to the broadly understood term of digitization of Polish public universities are discussed in this paper. Digitization affects almost every sphere of the university's activity – teaching, research, civil and administrative law domain in which it operates. The pace of digitization of Polish public universities varies, which may be due to the fact that the implementation of some solutions depends solely on the decisions of the given university's authorities as well as that university's organizational and financial capacity. However, to a large extent, the process of university digitization is “forced” by the introduced or amended regulations of the law, requiring the adaptation of the principles of university operation to the rules of digital legal reality. Regardless of the time and method of implementing IT tools, there is no doubt that the digitization of Polish public universities is a process that cannot be stopped and cannot be avoided.

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The analysis of the impact of research activity on society and economy with the use of topic modelling

Paweł Lula¹, Magdalena Talaga²

Abstract. In 2022 the evaluation of the quality of research activity of Polish institutions of higher education sector was performed. During the assessment process three criteria were taken into account: publication activity, funds for research activity obtained by higher education institutions from external sources and the impact of research activity on society and economy.

The main topic of the paper is related to the third criterion and shows the results of the analysis of cases of impact reported by research institution. The analysis of documents describing social impact was performed with the use of the latent Dirichlet allocation method and was focused on identification of main issues covered by social impact activity and showing social impact profiles for selected Polish research institutions.

Keywords: quality of research activity, evaluation of higher education institutions, topic modelling, latent Dirichlet allocation method.

JEL Classification: I23, C55, C66.

1 Introduction

In the first part of the year 2022 the evaluation process of the quality of research activity of Polish higher education institutions was conducted ([The Law on Higher Education..., 2018]). These units were evaluated taking into account three criteria: publication activity, financial value of research projects carried out at these institutions and social impact of research activities. Assessment process was conducted by the Commission for Research Evaluation. On the basis of the resolution of the Commission, the Minister of Education and Science decided to award the research institution with the appropriate scientific category (A+, A, B+, B, C). The category achieved has an impact on:

- the right to create and conduct study programs,
- the right to run doctoral schools,

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- the right to confer academic degrees,
- the amount of subsidy received from the state budget.

It is worth noting that the evaluation process was carried out separately within each scientific discipline.

The subject of this paper relates to the issue of assessing the social impact of scientific activity, which is a matter considered in the third evaluation criterion. In order to evaluate this aspect of scientific activity, the evaluated higher education institutions prepared case studies showing this type of impact. These documents were next reviewed by experts.

The aim of the research was to analyze the issues mentioned in case studies of the social impact of scientific activities conducted within the disciplines represented at the Krakow University of Economics and to compare them with issues reported by other leading Polish universities. Analysis of documents containing descriptions of social impact was carried out using the latent Dirichlet allocation (LDA) method.

The main aspects of the LDA method were presented in the second section. Next, in the third section, a short presentation of the research methodology was delivered. The fourth section contains the results of the empirical analysis. The work concludes with a summary.

2 Latent Dirichlet allocation method as a methods of topic identifications

In the first subsection of this part of the paper, the general idea of topic identification methods is presented. Next, in the second subsection, foundations of the latent Dirichlet allocation ([Blei et al, 2003]) method are discussed.

2.1 The general idea of topic identification methods

Let's assume that $D = \{D_1, D_2, \dots, D_M\}$ is a set of M documents composed of N unique words $w = \{w_1, w_2, \dots, w_N\}$. Topic identification method can be defined as a unsupervised machine learning algorithm allowing to identify topic defined as:

$$\Phi = \begin{bmatrix} \phi_1 \\ \phi_2 \\ \dots \\ \phi_P \end{bmatrix}$$

The ϕ_k topic can be defined as:

$$\phi_k = [\phi_{k,1} \quad \dots \quad \phi_{k,N}]$$

where $\phi_{k,j}$ is the probability of occurrence of the w_j word in the ϕ_k topic.

For every topic ϕ_k the condition:

$$\sum_{i=1}^N \phi_{k,i} = 1$$

is always true.

Topic modelling approach allows to present the contents of the D_j document as a combination of identified topics. The contribution of topics in documents is describe by the Θ matrix:

$$\Theta = \begin{bmatrix} \theta_1 \\ \dots \\ \theta_M \end{bmatrix} = \begin{bmatrix} \theta_{1,1} & \dots & \theta_{1,P} \\ \dots & \dots & \dots \\ \theta_{M,1} & \dots & \theta_{M,P} \end{bmatrix}$$

where $\theta_{j,k}$ is the probability of occurrence of the ϕ_k topic in the D_j document.

For every document D_j the condition:

$$\sum_{k=1}^P \theta_{j,k} = 1$$

is always fulfilled.

2.2 Latent Dirichlet allocation method

The latent Dirichlet allocation model assumes that the Φ matrix (the distribution of words in topics) has rows taken from the Dirichlet distribution:

$$\phi_k = \text{Dir}(\beta)$$

and the Θ matrix (the distribution of topics in documents) has rows taken also from the Dirichlet distribution:

$$\theta_j = \text{Dir}(\alpha)$$

The most popular way of calculation the Φ and the Θ matrices is collapsed Gibbs sampling method.

The LDA model has generative character. It means that it describes the process of document generation assuming that parameters (Φ and Θ) and the number of words (N) are known. This process can be presented in the following way:

for $j = 1$ *to* M *do*: # document id

for $i = 1$ *to* N *do*: # word id

for $k = 1$ *to* P *do*: # topic id

$z_{i,j} \sim \text{Multinomial}(\theta_j)$ #choose a topic

$w_{i,j} \sim \text{Multinomial}(\phi_{z_{i,j}})$ #choose a topic

3 Research methodology

The research process was composed of the following steps:

1. cases of impact for selected disciplines were downloaded from the web service <https://radon.nauka.gov.pl/>.
2. all documents were transformed to plain text format,

3. with the use of the latent Dirichlet allocation method, for every discipline, five main topics were identified,
4. services available at the <https://eppi.ioe.ac.uk/ldavis/> allowed to visualize relationships between topics and interpret them (by presenting lists of most relevant words for every topic and assigning labels /descriptions/ to them) (Figure 1),

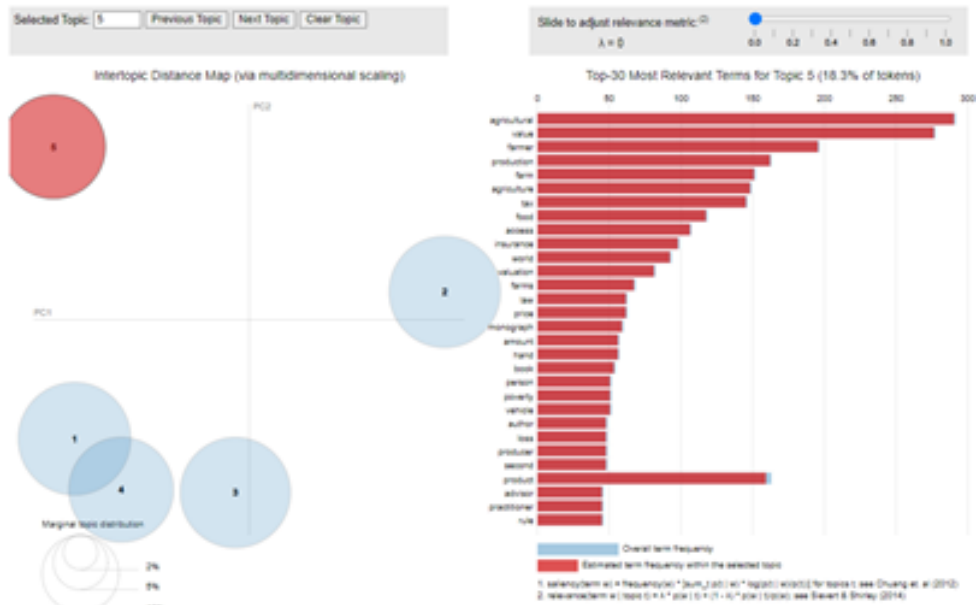


Figure 1 Presentation of topics. Relationships between topics on the left and topic characteristic on the right.

5. for all documents prepared in a given discipline, the significance of every topic was calculated and the results were aggregated for all documents prepared by every institution. In this way, the significance of topics for institutions was evaluated. The results were presented in graphical form,
6. the steps presented above allowed to formulate research conclusions.

4 Main topics mentioned in cases of impact within disciplines evaluated at the Kraków University of Economics

The scope of the analysis covers the cases of impact of research activity on society and economy prepared by Polish higher education institutions

(HEI) for the evaluation process carried out in 2022 in disciplines evaluated at the Kraków University of Economics:

- economics and finance,
- socio-economic geography and spatial economy
- political science and administration,
- law,
- management and quality sciences.

First, for every discipline six topics were identified with the use of the LDA method. Next, the significance of every topic for leading Polish HEI was estimated.

4.1 Discipline: economics and finance

In 2021 discipline “economics and finance” was evaluated in 47 Polish higher education institutions. These institutions submitted 113 cases of impact. The analysis of submitted documents allowed to identify topics presented in Figure 2.



Figure 2 Topics identified in cases of social impact within the “economics and finance” discipline

The Figure 3 presents the information about the significance of every identified topic in documents prepared by Polish leading public universities of economics.

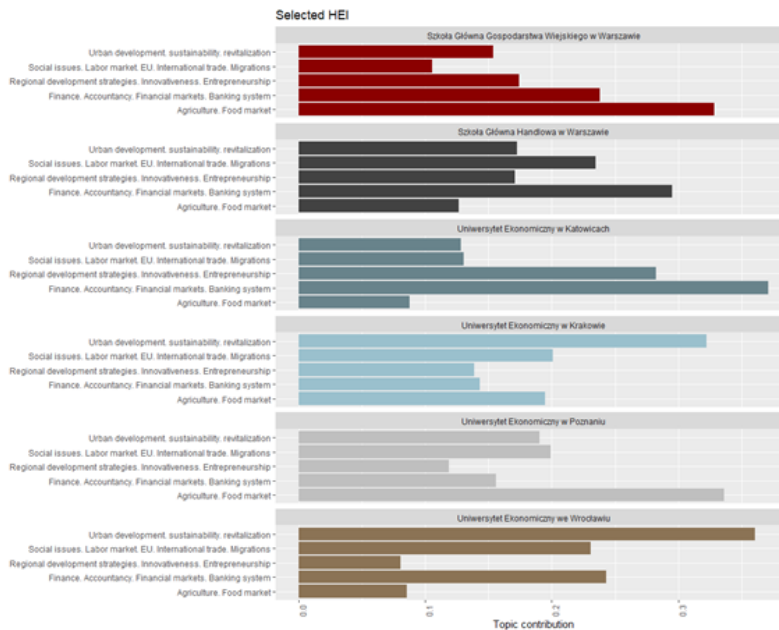


Figure 3 The distribution of topics' significance within the “economics and finance” discipline for selected Polish higher education institutions

4.2 Discipline: Socio-economic geography and spatial economy

Within the “socio-economic geography and spatial economy” 17 institutions were evaluated and reported documents presenting the social impact of their research activity. The total number of submitted documents was 38.

Main topics identified with the use of LDA method are presented in Figure 4.

The analysis of the impact of research activity on society and economy with the use of topic modelling

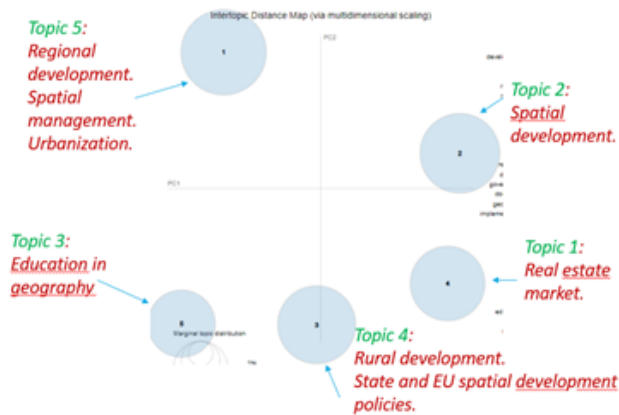


Figure 4 Topics identified in cases of social impact within the “socio-economic geography and spatial economy” discipline

After identification of topics, their importance for documents prepared by selected institutions was calculated. The results are presented in the Figure 5.

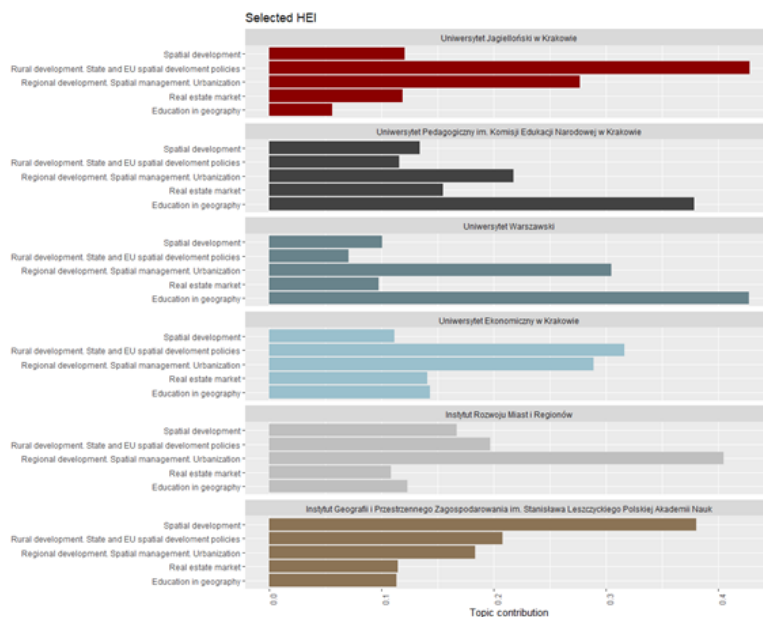


Figure 5 The distribution of topics' significance within the “socio-economic geography and spatial economy” discipline for selected Polish higher education institutions

4.3 Discipline: Political science and administration

The third research discipline evaluated at the Kraków University of Economics is “political science and administration”. This discipline is represented in Poland at 34 higher education institutions which prepared 76 documents describing cases of social impact. The results of the topic identification process are presented in the Figure 6.

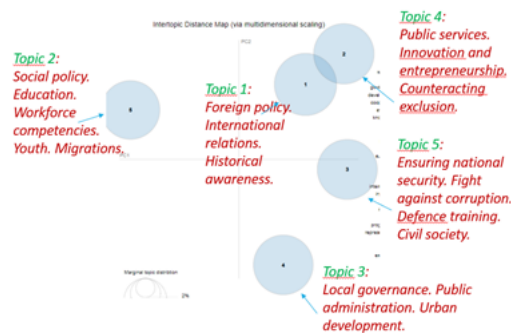


Figure 6 Topics identified in cases of social impact within the “political science and administration” discipline

In Figure 7, the importance of identified topics calculated for selected Polish universities, is presented.

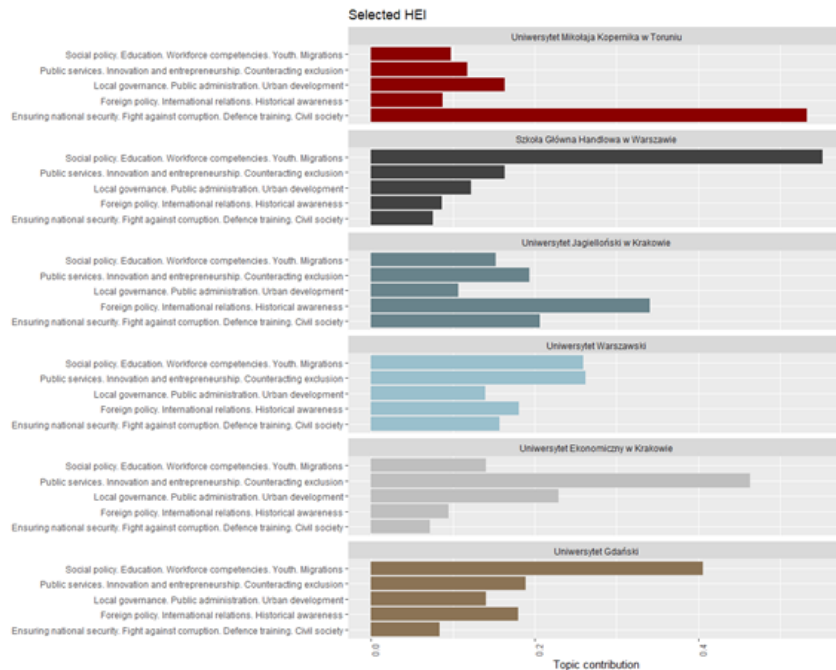


Figure 7 The distribution of topics' significance within the "political science and administration" discipline for selected Polish higher education institutions

4.4 Discipline: Law

41 Polish institutions were evaluated within the "law" discipline. Their social impact was assessed based on 96 reported cases of impact. The analysis of reports on social impact 5 main topics were identified (Figure 8).

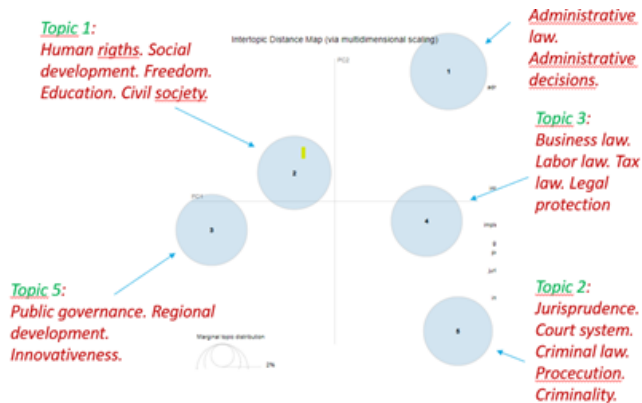


Figure 8 Topics identified in cases of social impact within the “law” discipline

In reported cases of social impact, a huge differences in significance of topics can be observed (Figure 9).

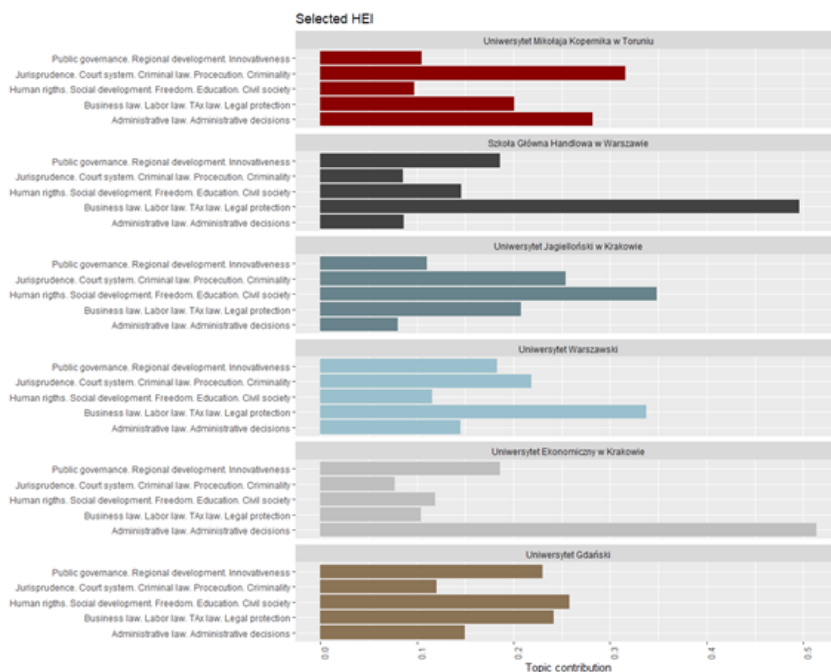


Figure 9 The distribution of topics' significance within the “law” discipline for selected Polish higher education institutions

4.5 Discipline: Management and quality sciences

The discipline “management and quality sciences” is represented at as many as 57 Polish institutions. And the total number of prepared cases of impact is 129.

Main topics mentioned in prepared documents are presented in Figure 10.

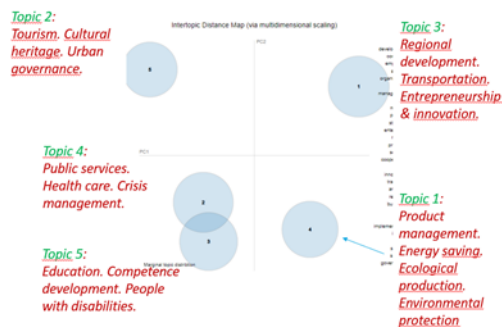


Figure 10 Topics identified in cases of social impact within the “management and quality sciences” discipline

Profiles of social impact reported by selected universities is presented in Figure 11.

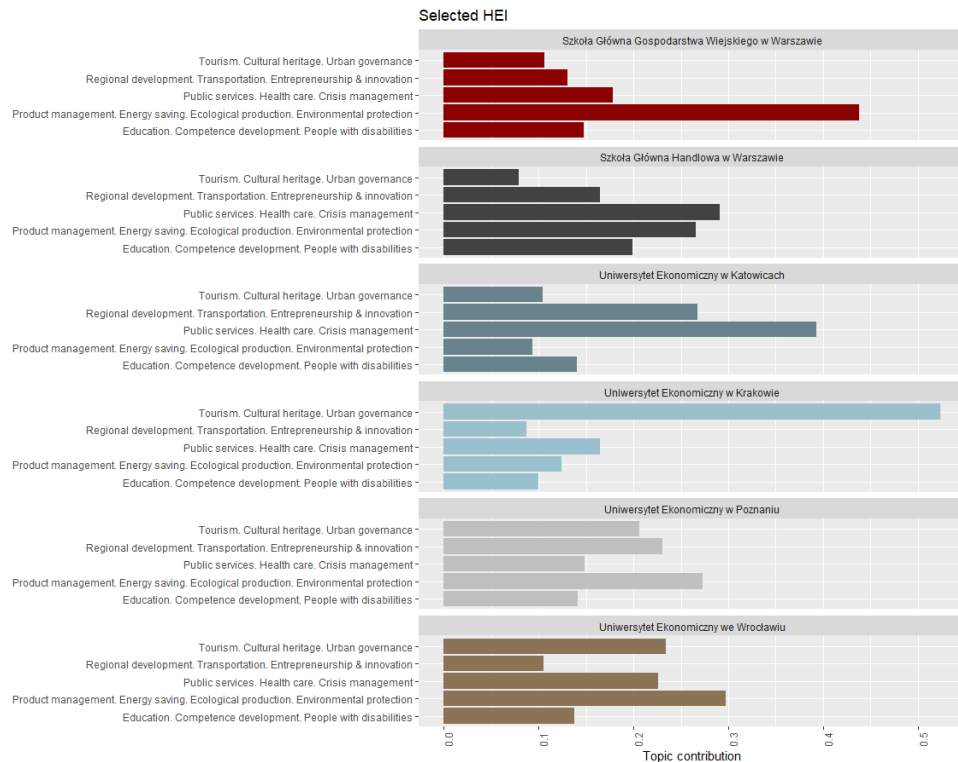


Figure 11 The distribution of topics' significance within the "management and quality sciences" discipline for selected Polish higher education institutions

5 Conclusions

The directions of development of higher education system show that the social impact of scientific activity will be an increasingly important criterion for evaluating universities. For this reason, continuous monitoring and evaluation of this aspect of research activities should be considered very important.

Taking the Polish system of evaluation of the quality of scientific activity as a basis, it seems that the topic modelling methods allowed to identify main issues reported by Polish universities as achievements evaluated as cases of impact on society or economy. The results achieved clearly show that the scope and strength of social impact of Polish universities in selected social sciences disciplines are diversified.

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Methods of measuring and controlling temperature and the possibility of their involvement for the formation of temperature subsystems

Andrii-Volodymyr Midyk¹, Olha Lysa²

Abstract. A study of the method of determining the coefficient of emissivity of the material, which allowed to develop an infrared pyrometer for high-precision temperature measurement for construction and agriculture, as well as heat fluxes, which in turn allows to characterize with high reliability thermal insulation, building materials and products. themselves, to create grounds for establishing the suitability of building structures and structures for compliance with national and international standards.

Keywords: Temperature measurement, Emissivity factor, Measurement accuracy, Temperature measurement, Pyrometer.

JEL Classification: C69, C99.

1 Introduction

The thermal energy radiated by the warmed body surface depends on the emissivity factor. Each object, whose temperature to be measured, has its material's surface with its inherent emissivity factor. Adjustment of the emissivity factor in a pyrometer or thermal image camera is essential in order to measure the actual temperature. It has to be done manually and match the measured object. Pyrometer always fixes the temperature of a measuring point, and a conversion based on the emissivity factor is performed.

Aim of the current issue is the creation and development of the method for determining the emissivity factor of a material's surface at the moment immediately preceding the temperature measuring stage.

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2 Method research

There is a method of determining the integral value of the radiative properties of materials based on the dependence: $\varepsilon = \left(\frac{T_P}{T}\right)^4$, where T_P – is the radiation surface temperature of the sample; T – thermodynamic temperature. Here, the measurement result is a significant error due to the significant heat dissipation on the electrodes of the thermocouple, and the value of the error increases with increasing temperature.

There is also another way to determine the integral value of the radiative properties of the material surface, which consists in measuring the intensity of radiant heat exchange, expressed in radiation temperature, attributed to the scale of the measuring instrument (pyrometer) during calibration, between the surface of the object. In this case, the calibration of radiation pyrometers is carried out according to the model of "blackbody", for which it is assumed that the coefficient of emissivity is close to 1. Since the real samples of controlled materials are characterized by certain values of the coefficients of emissivity other than 1, there is a significant error in the readings of the pyrometers, which is up to 10%. As a result, for one group of radiation pyrometers it is assumed in advance that they are operated at one value (0.95) of the coefficient of emissivity of the controlled material, or rather the reduced coefficient of the system "pyrometer - material" (it is entered below); for another group of more complex types of radiation pyrometers, this coefficient can be adjusted by a metrologist manually on the instrument panel in the range of 0.1 (0.3)... 1.0. It is clear that for both the first and the second group due to ignorance of the real value of the coefficient of radiance of the controlled material there is a significant methodological error.

To an even greater extent, the above applies to thermal imagers, which, as a result, allow to obtain only a qualitative picture of heat loss of the building. To avoid very significant errors, special tables are often used, which show the value of the coefficient of emissivity of various materials and the degree of surface treatment. For example, the presence of an oxide film on the surface significantly affects the coefficient of emissivity. Thus, the coefficient of oxidized steel is 0.85, and the coefficient of polished surface is 0.075.

The task was to create a method for determining the coefficient of emissivity of the surface of the material at the time immediately preceding the stage of

temperature measurement. So it can be considered a prerequisite for the correct precision measurements of the temperature of the object, beyond the determination of the coefficient of emissivity allows, using the above expression, from the measured radiation temperature, to calculate the thermodynamic temperature of the sample.

To do this, in the method of determining the integral value of the radiative properties of the surface of the material, based on Stefan-Boltzmann's law and consists in measuring the intensity of radiant heat transfer by a measuring instrument expressed in radiation temperature attributed to the scale marks means at a known temperature of the latter, the intensity measurement is performed twice, and the second time at a different temperature of the sensitive element, and the results of intensity measurements are subtracted from each other, obtaining a change in intensity, expressed in units of radiation temperature; In parallel with the intensity measurement, 2 alternating values of the temperature of the sensing element are measured, determining by their difference the increase in the temperature of the sensing element, the value of which, as well as the value of the radiation temperature change, calculate the coefficient of surface material.

3 Implementing the proposed method

First of all, consider the flow of energy E_0 , which is transmitted from the surface of the material by a radiant path to the pyrometer, more precisely to its blackened plate, which houses the energy receiver (thermocouple battery, bolometer, etc.). According to Stefan-Boltzmann's law, it is:

$E_0 = \sigma T^4; E_0 = C_0 \left(\frac{T}{100} \right)^4$, where $C_0 = 10^8 \cdot \sigma = 5,7$ [Watt/m²K⁴] – the coefficient of radiation of an absolutely black body. When a body is not black, but, for example, "gray", the required blackness factor or the coefficient of emissivity $\varepsilon \leq 1$ is introduced, which describes how much the radiation of this body is less intense than the radiation of a completely blackbody. Radiant heat transfer between 2 bodies (controlled surface of the area S with its ε_{nos} and the sensitive element of the pyrometer with its ε_{np}) is determined by the difference of 2 streams of effective radiation:

$$q = \varepsilon_{np} C_0 S \left[\left(\frac{T_{nos}}{100} \right)^4 - \left(\frac{T_{qe}}{100} \right)^4 \right], \quad (1)$$

$$\text{where } \varepsilon_{np} = \left(\frac{1}{\varepsilon_{nos}} + \frac{1}{\varepsilon_{ue}} - 1 \right)^{-1}, \quad (2)$$

given for a system of 2 bodies and depending on the ratio of the areas of radiation objects. Each value of q when calibrating the pyrometer is assigned a certain value of luminance temperature, because each design of the pyrometer has its own coefficient A conversion of energy flow into heating of the sensitive element, as well as further processing of the signal received from it to a specific radiation temperature. Note that the coefficient A must also take into account the value $C_0 S$. In this case, the calibration is carried out according to the model of a completely black body, trying to reach the conditions $\varepsilon_{np} \rightarrow 1$. As a result, you can get the equation of the transformation function of the pyrometer, expressed in terms of radiant heat transfer between its sensitive element and the controlled surface: $T_p = T_p(T_{nos}; T_{ue}; \varepsilon_{np})$. There are 2 unknowns in it – T_{nos} and ε_{np} . Therefore, the equation can be solved only by assuming that $\varepsilon_{np} \rightarrow 1$. However, this path leads to a significant methodological error.

When creating conditions for the preliminary determination of the reduced coefficient of emissivity in order to further obtain an unambiguous pyrometer conversion function in the form of $T_p = T_p(T_{nos})|_{T_{ue}=Const; \varepsilon_{np}=Const}$ at known temperature of the sensing element and the coefficient of emissivity. To do this, below is a system of 2 equations with the 2 mentioned unknowns, and the second equation describes the state of heat transfer between the surface of the controlled material and already heated by several degrees (ΔT) sensitive element of the measuring instrument:

$$T_{p1} = \varepsilon_{np} A \left[\left(\frac{T_{nos}}{100} \right)^4 - \left(\frac{T_{ue}}{100} \right)^4 \right], \quad (3)$$

$$T_{p2} = \varepsilon_{np} A \left[\left(\frac{T_{nos}}{100} \right)^4 - \left(\frac{T_{ue} + \Delta T}{100} \right)^4 \right], \quad (4)$$

Subtracting from (3) equation (4), we obtain:

$$\Delta T_p = \varepsilon_{np} A \left[\left(\frac{T_{ue} + \Delta T}{100} \right)^4 - \left(\frac{T_{ue}}{100} \right)^4 \right] \quad (5)$$

Given that the hot junctions of the pyrometer thermocouple battery are preferably located on a platinum petal covered with platinum black, realizing the conditions for achieving $\varepsilon_{ue} \rightarrow 1$, from equation (2) it is seen that $\varepsilon_{np} \approx \varepsilon_{nos}$. Then equation (5) is reduced to the following equation:

$$10^8 \Delta T_p = \varepsilon_{nos} A [4T_{ue}^3 \Delta T + 6T_{ue}^2 (\Delta T)^2 + 4T_{ue} (\Delta T)^3 + (\Delta T)^4] \quad (6)$$

With an error $\left(\frac{\Delta T}{T_{ue}}\right)^2 \approx 10^{-4}$, when 1% of T_{ue} , for practical calculations it is

enough to use the first two members of the polynomial:

$$10^8 \Delta T_p = \varepsilon_{nos} C_0 S [4T_{ue}^3 \Delta T + 6T_{ue}^2 (\Delta T)^2] \quad (7)$$

From this we obtain the expression for calculating the coefficient of emissivity of the surface of the material:

$$\varepsilon_{nos} = \frac{10^8 \Delta T_p}{A [4T_{ue}^3 \Delta T + 6T_{ue}^2 (\Delta T)^2]} \quad (8)$$

First of all, we assume that to ensure the efficiency of the method and the simplicity of further calculations, an increase in the temperature of the sensitive element equal to 1% of T_{ue} is established. Then expression (8) will be simplified to:

$$\varepsilon_{nos} = \frac{10^8 \Delta T_p}{0,0406 \cdot A \cdot T_{ue}^4} = \frac{\Delta T_p}{0,0406 A \left(\frac{T_{ue}}{100}\right)^4} \quad (9)$$

When the measuring instrument together with the sensing element is at a temperature of 293 K, then for calculations you can get a fairly simple expression:

$$\varepsilon_{nos} = \frac{2,9924 \Delta T_p}{K^4 A}, \quad (10)$$

where A [1/K] – the conversion factor of the radiant energy flux into a pyrometer display under the conditions given in the technical conditions for the device.

4 Conclusion

1. A study of the method of determining the coefficient of emissivity of the material, which allowed to develop an IR pyrometer for high-precision temperature measurement for construction and agriculture, as well as

heat fluxes, which in turn allows to characterize with high reliability thermal insulation, building materials and products. themselves, to create grounds for establishing the suitability of building structures and structures for compliance with national and international standards.

2. The developed method can also be used in the process of calibration of technical pyrometers, ie in the field of non-contact temperature measuring instruments, namely radiation pyrometers, in the field of high-precision temperature measurements in industrial and laboratory conditions. significantly increase the accuracy of temperature measurement. This is achieved by determining said coefficient of the substance by repeated measurements of the same body surface by targeting the temperature of the sensitive element of the measuring instrument using an independent heat source.

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Current sustainability development of the power plants in Slovakia

Jana Vajdová¹

Abstract. The study deals with the state and perspectives of bioenergy and focuses on several possible profitability scenarios and the future development of Slovak power plants in a competitive electricity market. The aim of the paper is to propose alternative scenarios and forecast the development of Slovak power plants. Within the methodology were also identified the factors influencing the price of electric energy (EE) on the market and subsequently the profitability of power plants. Scenarios for the future development of EE prices were identified using the statistical method FORECAST.FUNCTION. Despite the predicted increase in the market price of EE it is possible to assume a favourable development of Slovak power plants and maintaining their future competitiveness on an international scale. The relationship and their extent of influence between coal, emission allowance and oil prices, determining EE prices, were quantified by regression analysis and Analysis of Variances (ANOVA). The paper contains current data from available databases and market forecasts and the absence of analyses for economic development, sustainability, and competitiveness of Slovak power plants in the unfavourable period of the ongoing COVID-19 pandemic and war conflict Russia-Ukraine.

Keywords: merit order principle, electric energy, sustainability, development, competitiveness.

JEL Classification: Q21, Q31, Q41, Q47.

1 Introduction

After the turbulent end of 2021, the markets expected the new calming to come. However, it did not take long and there was a shock not only for the stock exchanges. It remains to say that Russia's invasion of Ukraine is pushing markets to new extremes. The sharp rise in EE prices at the end of 2021 had several reasons: from the economic uprising to the pandemic, through reduced supplies to the market to stock market speculation. Part of the price rise was also caused by the EU's decisions to invest in green energy. However, in February of this year, it became clear how sensitively commodity markets react to geopolitical events. Currently, it is very difficult

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to buy energy for customers and suppliers are unable to provide their customers with fixed, so-called forward prices. Customers can order energy at spot prices, i.e., prices that are very different and less predictable in a day-to-day comparison (Hicks, 2022). In previous years, power plants gradually sold electricity, but today they have suspended sales because it is not clear whether Russia will supply enough gas for heating and electricity generation. Since the beginning of the conflict, a higher volume of gas has been flowing into the EU from Russia, which is helping to calm the situation. However, if gas supplies were to fall, the market would react immediately to soaring prices. Currently, the stability of supplies for the near future is particularly important.

2 Theoretical background

The current study provides stakeholders with various managerial implications for improving the competitiveness of the entire value chain in an emerging market. If companies want to improve and develop a sustainable policy in the national and international market, it is necessary to understand its principles and work in accordance with these requirements to support their performance.

2.1 Merit order electric energy pricing principle

The Slovak EE market is part of the EU market, which is currently undergoing dramatic changes. The market structure is characterized by a high degree of liberalization and integration, given the diversity of national energy policies and mixes. The Slovak competitive environment is not isolated but can be determined in certain circumstances by the markets of Germany, France, Austria, the Czech Republic, Poland, Hungary, and the Balkans. Liberalization and the diverse integration of national policies and mixes with EE have made competition a decisive factor. All individual production capacities compete (Stričík & Čonková, 2021). EE pricing in wholesale markets is determined based on the merit order principle (Figure 1).

Looking at the curve, we can say that increasing the supply of energy from renewable sources will reduce the settlement price (with the same demand curve) and push more expensive units out of the market. That is why

wholesale prices in Germany, for example, have fallen sharply since the beginning of the energy transformation. Also in Belgium, wholesale prices have fallen in recent years. This does not necessarily translate into lower electricity bills for the final consumer, as the energy component makes up only one third of the bill. The other two thirds are taxes, levies, and distribution tariffs (Fleschutz et al., 2021).

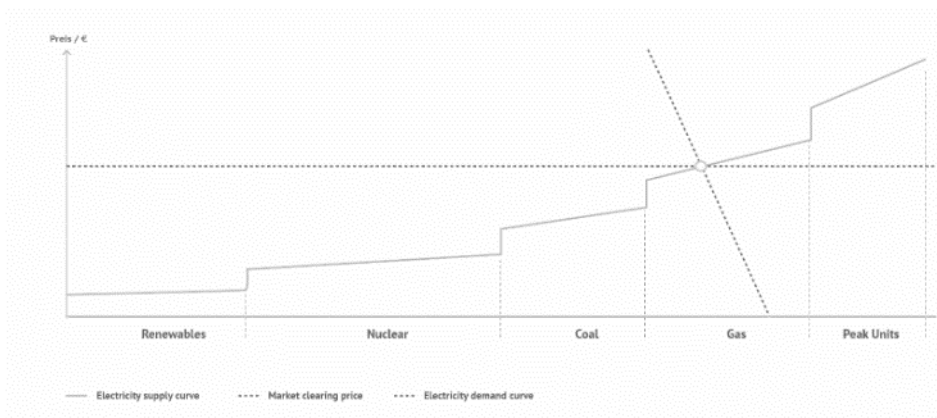


Figure 1 Scheme of merit order principle. Source: own research Next-kraftwerke (2022)

The power plant receives its marginal costs for market settlement, while for other power plants the settlement price is higher than their operating costs. The difference between the settlement price and the marginal cost is known as inframarginal rent. Inframarginal rent is needed to cover fixed production costs. The technology will only be attractive to investors if the market settlement price is for the most part higher than the sum of marginal and fixed costs. Investment in production capacity is key to security of supply. Network operators may introduce capacity mechanisms to reduce investment risks in generation capacity (Skene, 2022).

The variable costs of RES (except biomass) are practically low to zero, so they are on the left and their power is distributed only based on meteorological conditions (as they are intermittent - they depend on the current weather conditions). In addition, they benefit from the preferential connection and mandatory purchase provided in the framework of RES support (Kaczmarzewski et al., 2021). This is followed by nuclear power plants and, at current fuel and emission allowance prices, lignite, and hard

coal power plants. Gas-fired power plants are currently the most expensive and are therefore operated at the lowest rates (Arora & Mishra, 2021).

Deployment of power plants is based on their position - the higher the variable costs, the less time they require by the market. The wholesale price of EE is thus formed at the junction of the demand and supply curves. The market price reflects the amount of variable costs of the last power plant, which is still needed to cover the demand (so-called price-setting / marginal plant, or marginal power plant) and is valid for all producing power plants (on the spot market it will be paid all satisfaction in the business hours). The price of electricity from a particular power plant can be different at different times. At present, we are still unable to store enough EE, so its consumption must be balanced with its supply, and for this reason, only electricity from certain sources is usually sold on the stock exchange (Koscha & Blechb, 2021).

The German wholesale market is the most important and most liquid in the region, serving as a reference for other markets. A high level of integration and liberalization of the European market plays an important role. Germany's next-year base-load contract is considered a benchmark for the rest of continental Europe (like spot markets). The reason is the size of the German market and the diversity of market players together with the location of Germany. The distribution of electricity from power plants in the region depends on the German merit order principle and on demand (Buescher et al., 2022).

2.2 Development of electric energy prices

The possibility that the world will impose an embargo on Russian gas, coal, and oil catapulted electricity prices to new records in mid-March. These movements show all the signs of the panic that has prevailed in the market. However, it quickly became clear that at least the EU's leaders would not allow themselves to jeopardize their countries' economies by the lack of gas that would prevail once the Russian taps were completely closed. Over the past year, weekly average electric energy prices have risen from about 50 to almost 350 e/MWh (Innogy, 2022).

From the point of view of energy, a stronger dollar makes the prices of coal more expensive, which is traded in dollars and at the same time enters

electricity prices. Gas prices also correlate with the prices of liquefied gas LNG, which is also traded in dollars. In normal times a stronger dollar means slightly higher energy prices. The fact that the increase in gas prices was the main driver of electricity prices in the years 2019 to 2021 is also confirmed by the authors Kosch and Blech (2022).

Energy prices are now strongly influenced by the geopolitical situation in Ukraine, from which various concerns and threats arise, and these enter energy prices through an extremely high-risk premium. The main risk is a reduction or complete interruption of gas and oil supplies from Russia. Just such a possibility increased gas prices and electricity prices to historical records two weeks ago. This threat has not materialized yet, so prices have fallen rapidly. However, if this did happen, prices would rise even higher (Frey, 2022).

Another critical assumption of the forecast is that the development of gas prices, as well as the main competitors of coal and gas on the electric energy market, will be filled by the so-called the "heat gap" (the difference between electricity demand and nuclear and renewable electricity generation) (Andrews & Jelley, 2022).

This forecast (Figure 2) is therefore based on market expectations expressed through forward prices. As gas futures prices are relatively high until 2024, the share of coal in the energy mix will be more pronounced than we expected in last year's report. The level of coal production will largely depend on the size of the heat gap, which is largely determined by the growth rate of electricity production from renewable sources. This report reflects the results of the latest Renewable Energy Market Report (IEA, 2022).

In the case of the European market, where electric energy prices are set based on the merit order principle, the fuel costs of a marginal power plant are decisive. Therefore, cheap coal leads to a decrease in electricity prices at the moments when the coal-fired power plant is the coal one. Rising production from RES and stagnant or weakly increasing electric energy consumption increase the frequency of such moments. It follows that the more often a coal-fired power plant is a marginal power plant, the greater the impact of coal prices on electricity prices, regardless of the share of hard coal in total electricity production (in the case of the EU, the ratio of hard coal to electricity production is about 18 %) (Variny et al., 2021).

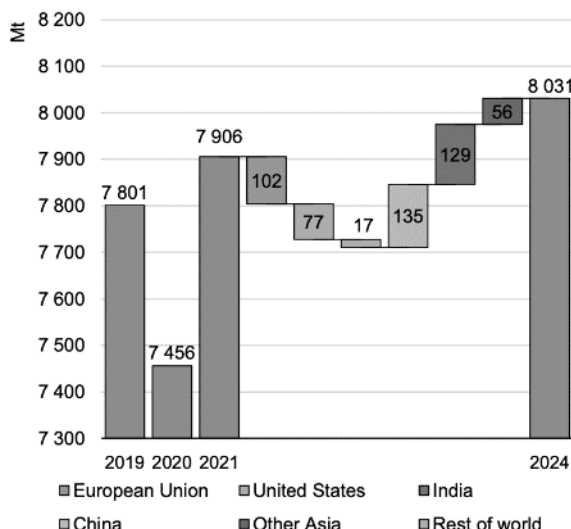


Figure 2 Changes in coal consumption by region, 2021-2024. Source: own research IEA (2022)

The effect is amplified by the high level of integration and liberalization of the European market. The high impact of coal prices on electricity prices is particularly visible in the case of the United Kingdom, Germany, and Eastern Europe. In the case of the USA, this relationship has been observed for decades, in Europe it is not so long ago. The impact increased with the development of expensive RES. Purchase prices of RES have changed the principle of merit order and therefore coal-fired power plants are increasingly the marginal power plant.

3 Methodology

The paper focuses on sustainable profitability scenarios and prediction of the competitiveness of Slovak coal-fired power plants. Within this study, possible future forms of the regional EE market are described and alternative scenarios of the operation of Slovak power plants are developed. Based on these scenarios, power plant owners can then decide on their future, adapting to market developments affected by new key factors in globalization, such as the ongoing COVID-19 pandemic and the Russian conflict in Ukraine. The

main reasons for the closure of power plants are the environmental impacts of EE production from coal and, despite the current rise in EE prices, they generate unsatisfactory economic results for power plants at the current rising coal prices and related emission costs.

3.1 Materials and Methods

The aim of the contribution is to propose the construction of alternative scenarios and future forecasts of the development of Slovak power plants in the context of achieving their sustainability and competitiveness in the current economic conditions. Using an analysis of the current state of the market and selected factors, the current reference scenario of the current development of EE was constructed.

The significance of the factors influencing the production of EE was confirmed by regression analysis. ANOVA was used to evaluate variability, which is a generalization of simple F and T tests on the agreement of variances and means. Subsequently, an analysis of scenarios was performed based on determining factors influencing the profitability and competitiveness of coal-fired power plants in the form of the development of EE prices. In the next step, possible future values of these factors were determined and using them, scenarios of future development of the situation are constructed. The development of EE prices with the prediction of their development was monitored using the statistical method FORECAST.FUNCTION within the Forecast analysis, based on which the conclusions were drawn in the context of the impact on profitability, sustainability, and competitiveness of the analysed power plants.

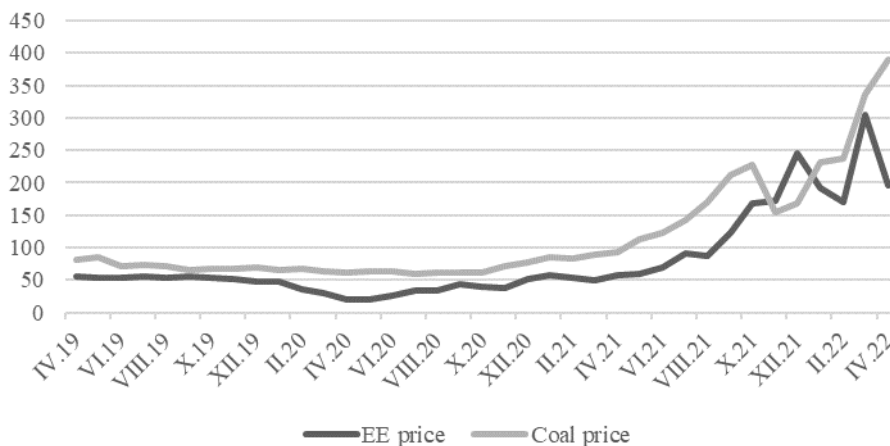
4 Results and discussion

EE trade and the regulatory framework for competitive markets need to be adapted to accommodate flexible conditions where an increase in EE prices reflects the social costs for the consumer, which should act as a signal for cleaner energy, as the associated marginal costs should be reduced, while the environmental benefits increase.

4.1 Determinants of electric energy price development

The potential effect of adverse causality between trade incentives in international markets and war conflict was also addressed by Ganegodage et al. (2014) who found that the war had a significant and lasting impact on national income, trade and the welfare of global economies with an emphasis on the negative impact on GDP (Balbaa et al., 2022).

The impact of black coal prices varies from country to country according to the ratio of coal costs to total variable costs, the frequency of coal-fired power plants as marginal power plants, the fuel mix and cross-border interconnections. According to RWE's analysis, the impact of coal prices on electricity prices is the second highest in Germany and the highest in Eastern Europe (Poland, Czech Republic, Slovakia, Hungary, Slovenia), 70 % - 80 % of the increase in coal prices is transferred to electricity prices. The effect is amplified by the high level of integration and liberalization of the European market. The high impact of coal prices on electricity prices is particularly visible in the case of the United Kingdom, Germany and Eastern Europe. The impact increased with the development of expensive renewable energy sources. Purchase prices of RES have changed the principle of merit, and therefore coal-fired power plants are increasingly a marginal power plant.



Graph 1 Development of electric energy prices and coal prices. Source: own research

Looking at price developments in the long run, price stability is visible. Especially before the corona crisis, were recorded sharp price jumps with the onset of the Russian-Ukrainian conflict. With this economic crisis, EE prices have risen, as has the increase in RES and limited global coal supplies, which have tightened further as Western sanctions have made trade in Russian coal more difficult. Electricity prices developed in parallel, graph 1 shows a very strong correlation between EE and coal prices

Table 1 Regression analysis (1)

<i>Regression Statistics</i>	
Multiple R	0.882236554
R Square	0.778341337
Adjusted R Square	0.772008233
Standard Error	38.40706244
Observations	37

Below the first value in Table 1, labelled "Multiple R," lies the Pearson correlation coefficient, which tells us how interdependent EE and hard coal prices are. A value of -1 represents an indirect dependence, 0 indicates independent phenomena, and a value of 1 represents a direct dependence. In the observed period, the correlation coefficient is closer to 1, so we are talking about a direct dependence. We can therefore confirm that the analysed EE prices in the observed period are directly dependent on the prices of hard coal.

The second value in the "R Square" table is the coefficient of determination (square root of the correlation coefficient) and represents how many % the result is correct. With our coefficient of determination $R^2 = 0.778341337$, the regression function can estimate the result correctly at about 77.83 %.

Table 2 ANOVA (1). Source: own research

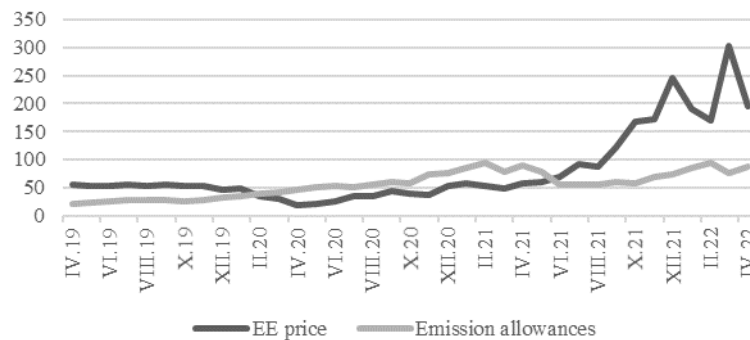
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	181290.737	181290.737	122.9004	0.03848

		51628.58	1475.10
Residual	35	55	245
		232919.3	
Total	36	22	

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	30.8487	9.930295	3.10653	0.0037	10.68921	51.008	10.6892	51.0083
X								
Variable 1	1.05086	0.094791	11.0860		0.858429	1.2433	0.85842	1.24330
	67	83	4	5.3385	05	04	90	43

Another important result of the regression analysis (Table 3) is the significance value F. If this value is less than 0.05, the results can be considered statistically significant. If the significance value of F is greater than 0.05, the results are statistically insignificant, for example due to insufficient data. Our result is roughly at the level of significance $F = 0.03848$, so the results are statistically significant. It can be seen from graph 2 that in most cases the prices of hard coal and electricity moved together, or with a short time lag, so we observe a strong correlation between the prices of both commodities.

The Emissions Trading Scheme (EU ETS) is a key instrument of European environmental policy. It is a form of carbon tax designed to support lower-emission technologies.



Graph 2 Development of electric energy prices and emission allowance prices. Source: own research

In Graph 2, we observe a weak correlation between EE prices and emission allowance prices. However, a possible increase in the prices of allowances has an impact on the price of electricity, as the price of allowances is affected not only by the demand for allowances, but mainly by political interventions in the system. We also support these arguments with Karimi et al., (2021), who explain the favourable impact of this factor through the environmental Kuznets curve, which suggests that economic activity initially worsens the environment, but with maturity the economy shifts to cleaner production. Electricity is an important source of production and fossil fuels are used to produce energy. However, the vulnerability of energy production can be reduced by increasing the share of renewable energy.

Table 3 Regression analysis (2). Source: own research

Multiple R	0.847075545
R Square	0.717536979
Adjusted R Square	0.709466607
Standard Error	10.81752495
Observations	37

In the observed period, the correlation coefficient is 0.454342836 (Table 3), so we speak of a weak direct dependence. We can therefore confirm that there is a dependence between the analysed quantities, but other external factors also intervene. The results may be due to the "non-standard" course of these last years. The second value in the "R Square" table estimates the result correctly at about 70.64 %.

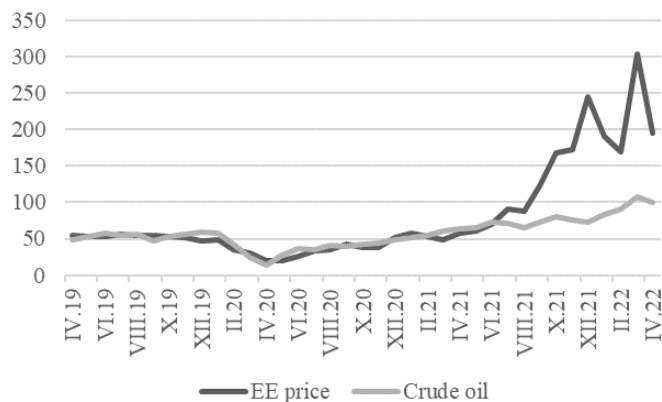
Table 4 ANOVA (2). Source: own research

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	3855.28183	3855.28183	9.10434603	0.004730174
Residual	35	14820.9288	423.455108		
Total	36	18676.2106			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	43.60930977	5.32052818	8.19642492	1.1725	32.808063	54.41055	32.80806	54.41055

X Variable	0.153245	0.050788	3.01734		0.0501	0.2563	0.0501	0.2563
1	557	28	089	0.0047	398	51	39	51

The result of the F-test value is roughly at the significance level of $F = 0.0047$, and thus we can conclude that the results are statistically significant. The influence of emission permits can also be demonstrated in the study by Foidart et al. (2021), who suggests that initial consumption of renewable energy will increase vulnerability to climate change. Transitioning to renewable energy will reduce a country's vulnerability to food, health and infrastructure. When renewable energy infrastructure is built, it will provide long-term benefits in terms of food security, public health and development. The price of oil affects other raw materials, especially coal and natural gas. The connection with natural gas is mainly due to the historical valuation method associated with oil prices.



Graph 3 Development of electric energy prices and oil prices. Source: own research

Graph 3 shows a significant correlation between oil and EE prices, which proves the previous statement. Given Russia's large share of oil exports, the Russian invasion of Ukraine is likely to lead to shocks in energy supplies and a steady rise in energy prices. This effect may be exacerbated if Russia imposes a retaliatory ban on energy exports.

Table 5 Regression analysis (3). Source: own research

Multiple R	0.847075545
R Square	0.717536979

Adjusted R Square	0.709466607
Standard Error	10.81752495
Observations	37

The closer 1 the coefficients calculated by regression analysis (Table 5), the stronger the correlation between the quantities. Prior to the Russian invasion of Ukraine, energy prices rose due to several factors, such as the COVID-19 pandemic, energy shortages and growing tensions between Russia and Ukraine. During this period, oil prices were stable in the price range of \$ 80 to \$ 95 before the invasion, so we assume, like Nesteruk (2022), that higher oil prices will mainly affect consumer spending as households spend more on their final energy consumption. This will result in lower household disposable income after tax, which will reduce consumer spending. This will affect consumer spending as a major component of GDP (Koengkan et al. 2019) and consequently reduce the rate of global growth.

Table 6 ANOVA (3). Source: own research

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	1	10404.148	10404	88.91	0.038566	0.038566		
		5	.14	002				
		4095.6596	117.0					
Residual	35	1	188					
		14499.808						
Total	36	1						

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	37.0704		13.25	3.327		42.7484	31.39238	42.74845
X	24	2.796913	40	3	31.39238	5	8	9
Variable	0.25174		9.429	3.856		0.30594	0.197545	0.305947
1	63	0.026698	21	6	0.197545	7	3	2

Since the value of F is less than 0.05 (Table 7), the results can also be considered statistically significant. The difference compared to the correlation between the prices of EE and hard coal is mainly in the fact that oil is not an important source of EE and so this correlation is rather secondary. It is the result of the above-mentioned valuation of natural gas linked to oil prices and, in turn, its substitute, hard coal, and at the same time

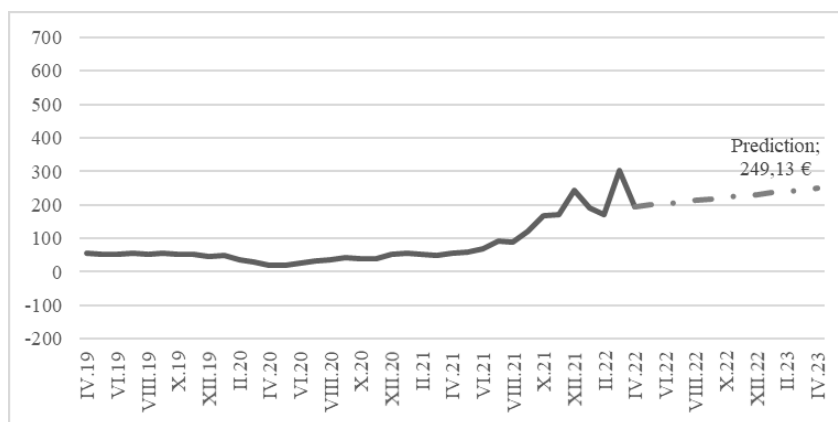
oil is a significant input in the production costs of coal mining. These factors may mean, for example, a time shift in this correlation, or a different degree of price change. Ozili (2022) came to similar conclusions in his analysis of the impact of oil prices on electricity prices. The price of electricity is not rising as smoothly as the price of oil, but rather alternates between slow and rapid growth, which is accompanied by higher volatility than in the case of oil

4.2 Analysis of scenarios of electric energy price development

A favourable scenario is a situation where the price of EE on the market will increase and the production costs of power plants will fall, which will make the power plants profit\ and the owner will continue to operate. The uncertain scenario assumes stagnation of consumption caused by average economic growth and a gradual increase in energy efficiency. Such stagnation will not cause a significant increase in demand or EE prices. It also assumes an increase in quota prices, which will increase the variable costs of coal-fired power plants, but based on the correlation, there should also be an increase in the market price of EE. With such an increase in the price of quotas, gas power plants would already be favoured, but there would be no change in order based on the principle of order of merit.

Furthermore, we assume a similar situation with the prices of coal, which are correlated with the price of oil and where there are significant changes in their market price and thus also in the market price of EE. Maintaining approximately the same amount of the supplement for burning coal would be a continuation of the situation for Slovak power plants, where the operator has only partially covered the production costs and is forced to produce even without an adequate profit. Adopting a change to the system of preferential access to RES in the system would not really help to remove market distortions in favour of RES, but the result would probably be better than the current situation. An uncertain scenario is a situation where EE prices in the market are at the limit of the operating costs of the power plants, so that the owner will hesitate to decide whether to continue operating the power plants or shut them down. The unfavourable scenario assumes a decrease in consumption caused by a slowdown in economic development and a significant increase in energy efficiency. This decrease will reduce both demand and EE prices. A significant increase in the prices of quotas will

bring about an increase in the variable costs of coal-fired power plants and will benefit gas-fired power plants, based on which they will alternate on the principle of merit. The drop in oil prices will also suppress EE prices on the market. The factor of low values of the price of black coal will also push down the price of EE on the market.



Graph 4 Expected development of electric energy consumption in SR. Source: own research

Regardless of the scenario (Graph 4), the owner may decide to implement the following regulatory negotiating recommendations and their enforcement may help to improve the competitive situation of the coal-fired power plants in his portfolio. Due to Russia's large share of oil exports, the Russian invasion of Ukraine is likely to lead to shocks in energy supplies and a steady rise in energy prices. While evidence shows that energy consumption and GDP are positively correlated (Stern, 2018), increased corporate spending on raw materials increases their production costs and consequently increases the price of outputs (Spasojević & Đukić, 2018). Therefore, aggregate demand will decrease due to a decrease in consumer purchasing power, which means less incentives for suppliers to produce more, therefore aggregate supply will also decrease, so this decrease in supply leads to a decrease in economic performance and growth (Muhammad et al., 2018, Lukasz Topolewski, 2021).

5 Conclusion

The contribution focuses on current issues of competitiveness of Slovak coal power plants. The global economic consequence of the invasion was the disruption of the global supply chain. This was reflected in rising consumer prices, including rising energy and commodity prices in euro area countries. Western intervention in Russia's struggle for territorial control may force Russia to impose an oil embargo in retaliation for Western sanctions against Russia. This could raise oil prices and affect economic growth. By reducing the regulatory burden on coal-fired power plants, the Government of the Slovak Republic can help find a solution to maintain production in these plants. The ever-increasing output of RES (especially in Germany) has the potential to push market prices of electricity downwards. However, Germany's gradual shift away from nuclear power plants and even the complete decommissioning of the nuclear power plant can reverse this trend.

The results of the study confirmed the hypothesis regarding more cost-effective combustion of solid recovered fuel at the Vojany black coal power plant in Slovakia compared to black coal. With this solution, the thermal power plant can achieve sustainable environmental and economic results. Authors confirmed the hypothesis that the power plant has the potential to produce synthetic fuel from pellets and biomass. This is evidenced by the experience of foreign studies and by the Slovak Republic moving in a sustainable direction in this area. When developing proposals to increase the economic and environmental efficiency of operating units, were expressed operating costs, which include material and energy costs. As part of the research, were proposed to focus on reducing the costs associated with emission quotas and transport in the distribution of alternative fuels. Based on the above findings and critical research, authors could say that co-incineration of solid recovered fuel in the production of electricity is possible from a technical, legislative and economic point of view (Štofová, Szaryszová, & Mihalčová, 2021).

The set aim of the contribution is achieved based on the performed analyses and forecasts of the development of EE prices in comparison with other influential commodities on the profitability, sustainability, and competitiveness of power plants. To relevantly achieve this goal, the construction of alternative scenarios and the future forecast of the

development of Slovak power plants were proposed. The determined factors influence the profitability of power plants and at the same time the formation of the market price of EE. At the same time, unlike nuclear power plants, they sell their production on short-term markets, so they are also more affected by price volatility.

The achieved results presented in this contribution represent the basis for further direction of research in the field of EE price development and monitoring of significant factors that increase the intensity and frequency of global extremes resulting from events in international markets. These empirical findings represent complex solutions across model settings, which allows us to draw new conclusions about energy availability and affordability in line with the goals of sustainable development.

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INFORMATION MANAGEMENT AND INNOVATION

Expenditure of innovative technologies in the control and accounting process

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Abstract.

In today's conditions, the search for new innovative solutions that would increase the efficiency of the agricultural sector is becoming extremely important. The effective functioning of accounting in modern conditions is impossible without the use of the latest information technologies for collecting, processing and transmitting information. The introduction of the latest developments in the control and accounting process is the key to sustainable development of agriculture.

Keywords: innovative technologies, innovative development, agricultural enterprises, control and accounting process, innovation in agriculture, agro-innovation.

JEL Classification: O 32, Q19

1. Introduction

The current state of the agricultural sector is due to the global impact of technological modernization, which is not always appropriate and does not meet the real needs and capabilities of agricultural producers. Agrarian enterprises, striving to adhere to the basic principles of innovative development must take into account the features and capabilities of the domestic agricultural market and the need for environmental safety.

Innovative activity is an activity aimed at finding opportunities to intensify agricultural production and meet social needs in competitive products and services through the use of scientific, technical and intellectual potential. In Law and Ukraine "On innovation activity", noted that innovation - a newly formed (applied) and (or) improved competitive technologies, products or services as well as organizational and technological solutions of industrial, administrative, commercial or otherwise, which significantly improves structure and quality of production and (or) social spheres (On Innovative Activity: Law of Ukraine of 04.07.2002 №40-IV).

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Agricultural enterprises should be interested in combining their interests and efforts in the creation and application of new technologies in order to enter the domestic and foreign markets with competitive products.

Foreign scientists P. Drucker, B. Santo, and others made a significant contribution to the development of world scientific thought regarding the theory of innovations. Features of the economic essence of innovative development of the agricultural sector of the economy are considered in the works: O. Datsiy, O. Kot, V. Savchuk, M. Sadykov, etc.

In particular, Datsiy O. (2002) clarified the definition of "innovation in agriculture" as "a change in technology, technology, organization, ecology, economy, as well as in the social sphere in order to obtain an economic effect aimed at meeting certain social needs of human existence."

Sadykov M. (2002) considers innovation in terms of agricultural production and notes that "the essence of innovation is to find a new, unconventional way to achieve the goal, ie in relation to the problem under study - ensuring the economy and environmental friendliness of modern agricultural production.

In work, disagreeing with some scientists, Kot O. (2008) noted "agro-innovation" as a systematic introduction into the agricultural sector of research results that lead to positive qualitative and quantitative changes in the characteristics of the relationship of bio - and technosphere and improve the ecological state of the environment.

The essence of the concept of "agro-innovatsiya" is identified as "innovation in agriculture", then consider that the content of the categories defined by the author, as the implementation in agriculture technological, technical, organizational, economic, environmental and other innovations for profit and meeting social needs (Andrushko R. and Myronchuk Z. 2019).

Thus, in a narrower sense, agroinnovation is the implementation in economic practice of research and development in the form of new technologies, new approaches to management, marketing, logistics, which increase production efficiency and product competitiveness.

Most of the enterprises of agro-industrial complex do not single out such an object of management accounting as innovation costs, there is no established system of operational control.

2. Expenditure of innovative technologies in the control and accounting process

In today's conditions, the search for new innovative solutions that would increase the efficiency of the agricultural sector in market conditions becomes extremely important. Participants in the innovation process should be interested in combining efforts to create new knowledge and technologies in order to enter the domestic and foreign markets with high-tech products.

Effective functioning of the accounting system in modern conditions is impossible without the use of the latest information technologies for collecting, processing and transmitting information. All development in this area based on the use of information technologies including geographic information systems, which are used for collecting, storing, processing and distribution of spatial data to make informed management decisions (Zhuk V. 2011).

The introduction of the latest developments in the control and accounting process is the key to sustainable development of agriculture. Innovation is a specific object of management accounting and requires operational control in the agricultural enterprise.

At the local level, a large number of geographic information systems are offered, which are adapted for management decisions and accounting systems in agriculture, in particular: MapInfo, Atlas GIS, ArcView and others. Arc GIS and ArcView with special operational accounting modules, 3D image output, and spatial analysis have become the most widespread in the domestic market. Arc GIS and Map info Professional geographic information systems with a wide range of tools for creating electronic maps.

The use of geographic information systems in the accounting of agricultural enterprises has made it possible to introduce innovative methods of agriculture. One such technology is "Precision Farming", which became widespread in European countries in the 90s of last century and is recognized by world agricultural science as an effective way to save resources and reduce the negative environmental impact of production. Technologies of precision farming are based on the analysis of each field: determination of features of a relief, agrochemical structure of a soil cover and application on each site of a field of various agro technologies. Based on the biological needs of plants, a normalized dose of mineral fertilizers is applied only in those areas that require it. All this provides significant savings in mineral fertilizers and reduces the likelihood of environmental pollution.

The positive effect of the introduction of these innovative accounting technologies is achieved by using multifunctional integrated systems that contain a variety of materials and data: digital topographic maps of agricultural land, soil information, digital terrain models, meteorological observations, statistics and more.

However, the efficiency of these systems is directly proportional to the scale of enterprises and the volume of agricultural production.

Automation of accounting at the lower level can be done by GPS-navigation methods, which requires a much smaller amount of investment, but accordingly provides a smaller range of information support for decision-making. The collection of information for the operation of such systems is carried out using hardware monitoring, which provide reception of GPS signals, collection of measurements from installed sensors and transmission of indicators to the database server.

As a result of the use of GPS-technologies, a certain set of indicators is transferred to the accounting system, which allows to perform all necessary operational management functions, such as planning of technological operations, control over equipment, resource use, compliance with technology, operational analysis and more.

Modern software that serves GPS- navigators, in real time gives the accounting specialist a set of indicators: location of equipment, speed and direction of its movement, distance traveled (cultivated area), fuel consumption and residue at a particular object of observation, creates conditions for control of primary documents on production of agricultural products. This allows you to remotely control and regulate the operation of a single unit of equipment, analyze the efficiency of technological operations, eliminate the additions of mechanics, helps to save fuel.

In order to increase the efficiency of agricultural enterprises and management decisions to make informed decisions, we propose to organize the accounting of costs for agro-innovation in the following sequence, Fig. 1.

The organization of operational control of innovation activity of agro-industrial enterprises provides for the following tasks (Andrushko R. 2020):

- protection of assets and property;
- reliability and reliability of information;
- resource efficiency;
- help and managers in achieving the intended objectives.

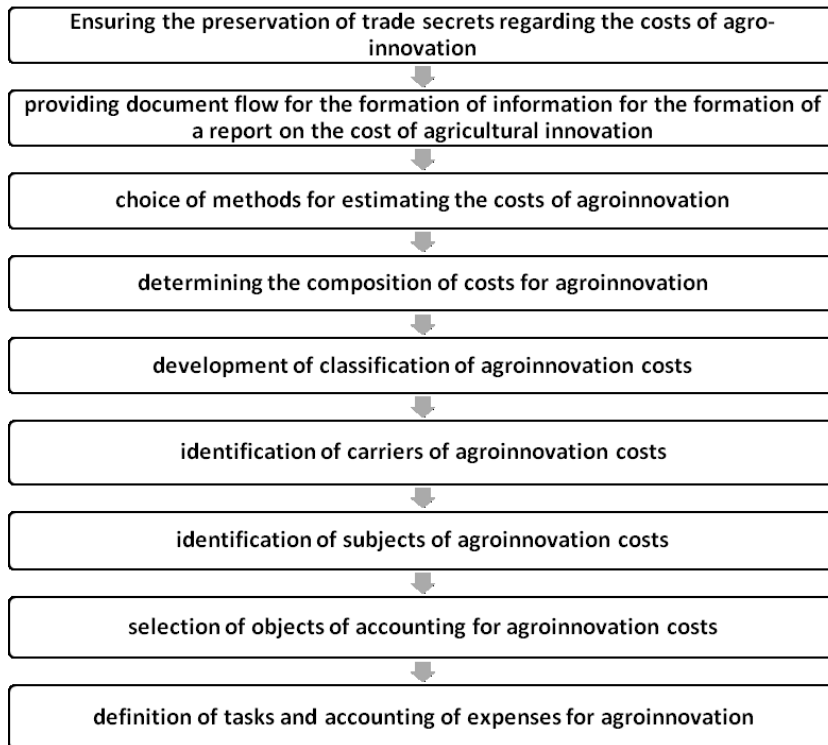


Figure 1 The process of organizing cost accounting for agro-innovation

To conduct high-quality operational control of innovation, it is advisable to develop a general methodology for identifying the magnitude of deviations of actual innovation costs from the planned. This will reduce the level of innovation costs as a basis for improving the efficiency of agricultural enterprises., Fig. 2.

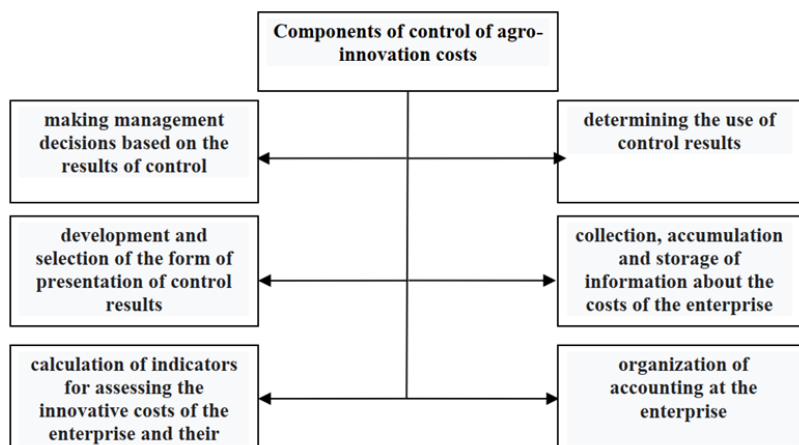


Figure 2 Components of operational control of agro-innovation costs.
Source: generated by the author.

And when selecting agro-innovative projects to conduct a deep economic examination. Evaluate efficiency indicators and work out schemes for promoting the obtained results in production.

A weak link in the formation of effective innovative development of agricultural enterprises is the study of demand for agro-innovation. Marketing should become an integral part of the formation of orders for research and development.

3. Conclusion

The introduction of the latest developments in the control and accounting process is the key to sustainable development of agricultural enterprises.

Innovative activity is an important component of the system of measures to accelerate the development of agricultural enterprises, increase their efficiency and competitiveness of products.

Effective enterprise management involves obtaining information about the costs and benefits that can bring certain innovation processes and products. The practice of recent years proves that the current level of accounting for the cost of agro-innovation is not able to meet all the requirements of today in full.

A weak link in the formation of effective innovative development of agricultural enterprises is the study of demand for agro-innovation.

Marketing has not yet become an integral part of the formation of orders for research and development. As a rule, in-depth economic expertise is not conducted during project selection, efficiency indicators and risks and schemes of promotion of the obtained results into production are not evaluated. This leads to the fact that many innovative developments do not become an innovative product.

All participants in the innovation process should be interested in combining interests in the application of new technologies in order to enter the domestic and foreign markets with high-tech products.

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Use of accounting software for reporting international accounting standards

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Abstract. The present time offers more and more virtual and digital possibilities. As part of digitization, many business units nowadays use accounting software for accounting. The aim of the post is to point out a vacancy in the market for individual accounting software companies that offer accounting to business units according to national accounting standards, but do not provide accounting according to international accounting standards. Companies that provide accounting software are thus offered a new open opportunity to expand their product portfolio. The accounting of business units within the Slovak Republic is specified in more detail by Act No. 431/2002 Coll. on accounting as amended. This law also specifies the possibility of accounting at the national level. Currently, business entities that carry out their business activities in the Slovak Republic can account using two types of systems, namely simple accounting or double-entry accounting. Based on the ever-evolving trends, small and medium-sized enterprises have the opportunity to use international accounting standards in order to apply on the international market. These standards were approved by the European Council and the European Parliament in 2002. The contribution approaches various possibilities of transformation of national accounting standards into international accounting standards.

Keywords: Accounting software, IFRS, IAS, accounting.

JEL Classification: O30, M40, M41

1. Introduction

The concept of accounting began to develop in ancient times. Individual parts of accounting are adjusted continuously through constant amendments. On the basis of constant digitization, accounting units currently use mainly

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accounting software to account for accounting cases that arise in individual companies. Since the competition in the market for accounting software is great, individual companies that offer such accounting software must react flexibly not only to legislative changes, but also to the development of new trends in order to be able to progress and thus create a competitive advantage. Currently, individual software offers its customers various functions, such as monitoring financial analyzes in the company, automatic connection and accounting between the bank and the software, creation of payment orders, automatic accounting of purchased goods to individual stock cards.

With the entry of individual countries into the European Union, individual accounting units have the opportunity to account using International Accounting Standards (IAS) and International Financial Reporting Standards (IFRS). However, this possibility is not used by any small and medium-sized enterprises in the Slovak Republic. The main reason may also be the fact that no accounting software currently provides for IAS/IFRS accounting. However, in the event that these small and medium-sized enterprises would like to expand to foreign markets, such accounting would bring them a considerable advantage. The disadvantage is that accounting software does not yet provide the transformation of national accounting standards into international accounting standards. Therefore, a small and medium-sized enterprise would have to carry out such a transformation on its own. The aim of the contribution is to observe whether the use of IAS/IFRS would really be beneficial for the company in view of the market position, or rather disadvantageous in view of the high costs?

2. Development of accounting

The development of accounting in the current Slovak Republic dates back to the founding of the First Czechoslovak Republic. However, the biggest change was recorded in 2002, when the European Parliament and the Council (EC) adopted 19 on July 19, 2002. Regulation No. 1606/2002 on the application of international accounting standards.

In 2000, the European Council at its meeting in Lisbon emphasized the need to create financial statements that would allow individual companies to be compared on an international level. These guidelines were to be completed by the end of 2005 at the latest. (<https://eur->

lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2002R1606:20080410:SK:PDF)

Regulation No. 1606/2002 on the application of international accounting standards was adopted, in addition to the European Parliament, by the European Council, which consists of individual heads of government and presidents of individual countries that are part of the European Union. The head of the European Council is elected based on the votes of individual participants for two and a half years. The meetings of the European Council mostly take place in Brussels.

With the accession of the Slovak Republic to the European Union, all European regulations issued by the European Parliament and the European Council became binding for the Slovak Republic as well. Based on successful ratification, the Slovak Republic became a member of the European Union on May 1, 2004.

The Slovak Republic currently uses national standards according to the valid Act No. 431/2002 Coll. on accounting as amended. This law specifies in more detail the possibility of keeping accounts in the Slovak Republic either through simple accounting or through double-entry accounting.

On the basis of Act No. 431/2002 Coll. on accounting as amended and Act No. 429/2002 Coll. as amended by later regulations on the stock exchange, IAS/IFRS are required to report financial statements based on international accounting standards:

- consolidated financial statements,
- individual financial statements (companies such as banks, insurance companies, securities traders, or selected large companies),
- issuers of securities.

Based on international standards, two basic types can be divided, namely:

- IAS - international accounting standards (which are older and were created during the years 1976-2003),
- IFRS - international financial reporting standards (which are newer and were created since 2004). (<https://www.iasplus.com/en/standards>).

According to the data obtained so far from the register of financial statements within the Slovak Republic, individual financial statements are prepared according to international accounting standards by 3 companies that carry out

business activities in the territory of the Slovak Republic (www.registeruz.sk). According to the current Slovak legislation, small and medium-sized companies do not have to present financial statements according to international accounting standards. It would be beneficial for small and medium-sized companies to use financial statements according to international accounting standards in case they want to expand to a foreign market. If they really wanted to report such statements in their accounting, it would be financially costly for them, as there is no exact transformation of national financial statements into international financial statements. Currently, within the Slovak Republic, some companies that specialize in this provide such a transformation.

According to data from the IASB (International Accounting Standards Board) and the IFRS Foundation, within the European Union, which currently has 27 member states, small and medium-sized companies in these member states can present financial statements adjusted according to IAS/IFRS, but they are not obliged to transformations. Thus, the European Union did not adopt IAS/IFRS standards within the European Union due to their incompatibility with accounting directives. (<https://eifrs.ifrs.org/eifrs/sme/en/IFRS%20for%20Smes> Standard 2015.pdf)

The use of IAS/IFRS throughout the world shows us the following Figure 1.



Figure 1 Countries in which companies appearing on the stock exchange must keep accounting according to IFRS, Source: IFRS Foundation, 2022

However, Figure 1 shows us countries that have not adopted IAS/IFRS for SMEs, but have adopted IFRS for all domestic listed companies.

3. Application of international accounting standards in the selected company

The reporting of financial statements with the IAS/IFRS specification represents a detailed and specific tracking of all items in the financial statements (Palea, 2013), (Ballweisser, 2009). Based on the expansion of its production and representation on foreign markets, the selected company is considering the introduction of financial statements through the use of international accounting standards, in order to be unique on the market, as no small and medium-sized company in the Slovak Republic currently prepares financial statements based on international accounting standards. The following example shows the difficulty of introducing, for example, only one type of international accounting standard. The given international accounting standard will be devoted to spare parts that affect the basic national financial statements, not only the Balance Sheet, but also the Profit and Loss Statement, as they reduce the economic result and at the same time increase the company's costs (Mirza, 2008), (Epstein et al, 2008).

The company's stocks are diverse, as it focuses on independent production (Cenigová, 2012), (Bartošová et al, 2018). Spare parts are part of the stock in the company, as he must have spare parts in his possession in his business activity in order to be able to respond in a timely and flexible manner to malfunctions of machines and equipment, which he classifies as separate movable items. According to IAS/IFRS, a company that has spare parts in its possession for more than one year should classify such spare parts as long-term tangible assets among separate movables (Haverals, 2007). Due to the fact that the company transfers these stocks (spare parts) to long-term tangible assets, the company is obliged to depreciate such long-term tangible assets (Zéghal et al, 2011), (Ankarath, 2010), (Epstein et al, 2008). The company's costs will thus increase by depreciation.

Based on the previous data, the company will have the following accounting operations, which will relate to the accounts that are expressed in Table 1:

Table 1 Transformational accounting operations to IAS/IFRS, Source: own

Property component	Accounting at debit side	Accounting at credit side	Property value in €
Transfer of spare parts from current assets to non-current assets	Increase in separate chattels	Stock reduction	4,956
Depreciation	Increase in depreciation of long-term tangible assets	Reduction of separate chattels	1,239

In addition to the above-mentioned items, individual items in the balance sheet, as well as in the profit and loss statement, will also change, as this international accounting standard also had an impact on the economic results (Wagenhofer, 2005), (Bellandi, 2012). Subsequently, the company must adjust the following balance sheet items (Paseková, 2012), which are shown in Table 2.

Table 2 Adjustment of individual balance sheet items, Source: own

Balance sheet item	Balance at the beginning in €	Change on the debit side in €	Change on the credit side in €	Balance sheet item after IAS/IFRS adjustment in €
Stocks	10,635		4,956	5,679
Current assets	72,183		4,956	67,227
Separate movables	8,256	4,956	1,239	11,973
Long-term tangible assets	8,256	4,956	1,239	11,973
Non-current assets	8,256	4,956	1,239	11,973
Total property	80,439	4,956	4,956	79,200
Profit	-1,954	- 1,239		-3,193
Equity	8,236	- 1,239		6,997
Total equity and liabilities	80,439	- 1,239		79,200

As can be seen from the above tables, the company correctly applied the international accounting standard. The operating result decreased from - 1,954 € to - 3,193 €, which made the company an even higher loss than without the introduction of international accounting standards.

Considering the difficulty and subsequent precision of applying one international accounting standard, it would be extremely difficult for a company to introduce international accounting standards on its own. When carrying out the transformation of national financial statements to financial statements according to international accounting standards, it would be more advantageous for the company to use a company that deals with such a transformation, so that there are no errors in the financial statements. However, it could be quite costly for a small business. The company is therefore considering other options for introducing international accounting standards through well-known accounting software.

4. The most used accounting software in Slovakia

With today's digitization, there are a large number of accounting programs related to the provision of such services in the Slovak Republic. An accounting unit can use external accountants for accounting reporting, but if it is a larger accounting unit, it is more advantageous for it to carry out accounting in-house. The accounting unit can thus decide which accounting software to use for processing its accounting. It only depends on the accounting unit whether it decides based on the reviews of users who already use the given accounting software, or whether it decides based on the amount of costs it has to put into the accounting software. In the following subsections, the individual most used types of accounting software in the Slovak Republic are characterized in more detail. At the same time, emphasis is placed on their advantages and disadvantages, while evaluating the expansion of accounting standards also on the basis of international standards. Companies that offer accounting software have been approached about providing or transforming national financial statements to international accounting standards. None of the companies interviewed provides software that would transform national to international accounting standards. At the same time, it points out their advantages and disadvantages, while evaluating the expansion of accounting standards also on the basis of international standards.

Accounting software POHODA

The company STORMWARE s.r.o. was established as a subsidiary in the Slovak Republic in 2001. This company provides customer support, either

through telecommunications or via e-mail. Currently, this company employs 39 employees and, in addition to the central company, also has 3 branches. At the same time, it should be pointed out that approximately 52,000 business entities are currently using this accounting software in Slovakia.

POHODA enables several softwares that provide different types of data processing for companies. The most widespread is the complete package, which provides, for example, simple accounting, double-entry accounting, invoicing, finances, etc. (<https://www.stormware.sk/pohoda/>)

Among the inherent advantages of this accounting program is expansion into the Czech Republic. Based on this, it can be concluded that the company that provides this accounting software has knowledge not only of national accounting statements within the Slovak Republic, but also has knowledge of national accounting statements within the Czech Republic. However, after communicating with the company that provides the accounting software, we learned that they do not provide reporting of financial statements via IAS/IFRS, nor are they currently considering it.

Accounting software Money

The company started developing accounting software in 1990. In 2001, they introduced the first version of the Money S3 program to the market, provided for small and medium-sized companies. However, the company is part of a holding company. The development was thus carried out not only within the Slovak Republic, but also within other countries that use the Money software. Thanks to the holding, today the company can present itself as the largest manufacturer of accounting software in the Slovak Republic, but also within the Czech Republic. Currently, 16,500 business entities use the Money software in the Slovak Republic. The company Money offers various accounting modules, such as: directory - clear display of customers and suppliers, bank and cash register, simple accounting, invoicing, etc.

The Money software tries to help its customers through the processing and recording of individual accounting statements. Other advantages include: creation of accounting analyses, enables both double-entry and single-entry accounting, ease of work through direct connection of the bank with the accounting program, etc. (<https://www.money.sk/produkty/ekonomicke-systemy/money-s3>).

Based on the facts mentioned above, it can be concluded that the company that provides this accounting software has knowledge not only of national accounting statements within the Slovak Republic, but also has knowledge of other national financial statements, as subsidiaries have their representation in several. However, after communicating with the company that provides the accounting software Money, we learned that they do not provide reporting of financial statements via IAS/IFRS and are not currently considering it, even though they offer their products in several countries of the European Union.

Accounting software KROS

KROS accounting software began to be developed in 1995. This accounting software is constantly adapting to new legislative changes in order to be able to compete in the market of companies that provide accounting software. Thanks to this, the program becomes more refined every year.

The company thus offers cooperation with various economic and construction schools, which can use selected software for the purpose of developing and educating the young generation. Currently, the company has established cooperation with more than 600 schools.

- Alfa + - to provide simple accounting,
- Omega – to provide double-entry accounting,
- Taxana – creation and calculation of individual tax returns,
- ikros – automatic work not only when filling out invoices,
- Olymp – creating payroll.

The Company in addition to economic software, the company also offers various construction software focused on digital construction, construction progress, construction projects, or construction valuation and management. (<https://www.kros.sk/>)

The company thus follows global trends and expands its packages not only within economic software, but also within other software. It also expands its offer to foreign markets, such as the Czech Republic. However, after communicating with the KROS company, we learned that they do not provide reporting of financial statements via IAS/IFRS, nor are they currently considering it.

Accounting software EcoSun

The company SunSoft was founded in 1991, but today it operates purely as a Slovak company. In 1993, with its development, it created its own economic software EcoSun, for simple but also double-entry accounting. The company SunSoft mainly provides the following economic software: double-entry accounting, invoicing and warehouses and payroll, etc. (<https://www.sunsoft.sk/software/ekonomicky-software/>)

The company that provides these economic software tries to satisfy its customers as much as possible. Therefore, in addition to constantly monitoring the amendment of Act No. 431/2002 Coll. on accounting, as amended, also follows new trends that are needed by individual entrepreneurs. Due to constant digitization, an economic program was developed to support online business. After communicating with this company, we came to the conclusion that SunSoft does not yet provide the creation of financial statements according to international accounting standards, but they want to fully satisfy their customers, therefore, in case of interest in the use of these international accounting standards in the company, they will also consider creating such accounting software. Currently, 1,700 customers use this program. This step would also be a competitive advantage against other companies that provide accounting programs.

Companies that offer individual types of accounting programs must follow all legislative changes and incorporate these changes into their products that they offer to customers. They must also monitor the development of digitization, which also affected the introduction of new functions into individual accounting programs, such as linking invoicing and warehouse management, or linking invoices with the bank within the framework of received payments and automatic posting, or issuing a request for payment, which the company submits through the linking of accounting program and the bank to pay the amount owed to the supplier or creditor. The development trend was noted by companies that provide accounting software also through the creation of new accounting software supporting online trading, as the number of online trades is currently increasing more and more due to the pandemic caused by the COVID-19 virus, as well as the convenience of individual consumers, or the increase in energy prices. Last but not least, it is possible to assume that some company that provides accounting software specializes in accounting through

IAS/IFRS for the sake of competition, since the regulation of accounting through international standards dates back to 2002. Currently, however, the current legislation does not mandate the keeping of financial statements based on international accounting standards.

Table 3 shows in more detail the individual differences in the selected accounting software.

Table 3 Comparison of individual accounting software, Source: own

The name of the accounting software	Expansion into countries	Number of users	Double-entry bookkeeping	Use of IAS/IFRS	IAS/IFRS in the future
Pohoda	CZ	52,000	Yes	No	No
Money	CZ	16,500	Yes	No	No
Kros	CZ	96,000	Yes	No	No
Ecosun	-----	1,700	Yes	No	Maybe

From Table 3, it is clear that all the selected companies that provide their users with accounting programs provide double-entry bookkeeping. In addition to the basic bookkeeping program, companies offer a wide range of support programs. Most users use various programs from the Kros portfolio. This fact can also be caused by the wide variety of programs offered. Of the selected compared companies that offer individual software in the Slovak Republic, Pohoda, Money and Kros expanded into the Czech Republic. However, none of the selected compared companies provides its users with IAS/IFRS accounting. Sunsoft, which offers Ecosun accounting software, mentioned after the communication that it will also consider the introduction and possibility of accounting according to international accounting standards due to the expansion of its portfolio.

5. Conclusion

The subject of the contribution was to introduce the concept of IAS/IFRS. At the same time, the aim was to point out the possibilities of applying international accounting standards in a small business. There are

three ways a small business can make the transformation. The first method is the application of international accounting standards in the company's own management. Although this form of application is the least expensive, if the company does not have a specialist who deals with such issues, a large error rate could occur during the transformation of national accounting standards into international accounting standards. The second variant of introducing international accounting standards into the enterprise was through a company that specializes in such a transformation. However, the costs in this case would be very high for a small business and the application of IAS/IFRS would not be effective in the business for this reason. The last third option was to approach individual companies that provide accounting software. They stated that they do not provide such a service at all yet, and only one company stated that it would consider the subsequent introduction of such a transformation of accounting standards in its accounting program.

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Methodology for processing econometric models using spss and microsoft excel programs

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Abstract. We consider econometrics as a scientific discipline that applies the tools of statistics and mathematics in the field of economics and uses computer science. The main reasons for the emergence of econometrics were the great economic crisis, criticism of economic research, the use of mathematics and statistics in economics. Thanks to the use of informatics, we can present the achieved results as well as information about econometric models. The achieved results in the form of tables and graphs are displayed with specialized software programs. Some of the most-widely used software packages include Microsoft Excel, Stata, R, SAS, and SPSS. These software programs will be compared in terms of the price of software packages, their features, and the classification of the area of application that describes a particular program. Based on the results, we determine which software is most suitable for certain areas of research..

Keywords: econometric modeling, economic factors, raw materials

JEL Classification: C50, C80, C87

1 Introduction

Satisfying human needs is inextricably linked to the mineral wealth of our planet. As the number of people living on Earth increases, pressure is not only placed on the limited mineral wealth, but many other problems also increase in importance. The problem, however, is securing all the necessary resources. Securing mineral resources is a demanding and complicated process requiring several decisions, both at the level of the state and at the level of companies operating in the raw materials sector. Decision-making can be characterized as one of the basic managerial activities. Its quality affects the results and efficiency of the entire company. Choosing between several variants can be quite complicated. Therefore, mathematical apparatus (mathematical models, econometric models) and various methods (timely planning, strategic management, price prediction) are used as a support tool for managerial decision-making, which help to make the right decisions. In

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this article, I will deal with the methodology of processing econometric models of the dependence of economic factors on the production of mineral resources using SPSS and Microsoft Excel programs. The input variable includes the production of mineral raw materials, and the output variables are economic variables (price, world population, gdp per capita and cumulative inflation). (Cipra, 2009), (Hančlová, 2012)

This methodology was used in a scientific publication entitled “The influence of economic factors on world production production”. (Černý, 2022).

2 Software for econometric modeling

In this chapter, the display of econometric modeling results using SPSS and Microsoft Excel programs will be clarified. The origin of the database, auxiliary calculations and ready-made econometric models will be explained.

2.1 Software for econometric modeling

Microsoft Excel is the most widespread and the most used spreadsheet in its class. It is used to create tables and graphs, analyze data, and create lists (databases).

Tests	Simple regression models			
The linear regression models				
	EMLIN1	EMLIN2	EMLIN3	EMLIN4
normality of residuals	rejected	rejected	not rejected	not rejected
mean value of residuals (zero)	not rejected	not rejected	not rejected	not rejected
significance of the model	not rejected	not rejected	not rejected	not rejected
significance of all regressors	not rejected	not rejected	not rejected	not rejected
correct model specification (RESET)	rejected	not rejected	not rejected	not rejected
homoscedasticity (exists)	not rejected	rejected	not rejected	rejected
autocorrelation (not significant)	rejected	rejected	rejected	it is rejected

Table 2 Microsoft excel- *Testing simple econometric models of dependence of world silver production on selected economic factors*, Source: Microsoft.com,2021.

Excel was used for testing econometric models. 7 tests were selected (Table 1): Model significance, significance of all regressors, correct model specification (RESET), normality test, mean value test (null), homoscedasticity, autocorrelation, and multicollinearity. In tests, it is decided whether the assumption is rejected or not. (microsoft.com, 2022).

Other factors that were calculated by the program are the coefficient of determination, standard deviation, and information criteria (Table 2). In the article (Table4) both according to the coefficient of determination and according to the minimization of the sum of information criteria show that the best values are recorded for econometric models created with the help of exponential regression (EMEXP1, EMEXP2, EMEXP4) only in the case of the EMEXP3 model, where the explanatory variable is GDP, this regression form ranked second behind the EMPOW3 model, which is built by power regressions.

<u>Coefficient of determination</u> (R^2)	<u>Standard deviation of the residual component</u> ($s_u(k)$)	<u>Criterion AIC(k)</u> $\min(\ln(s_u^2(k)) + 2k/n)$	<u>Criterion BIC(k)</u> $\min(\ln(s_u^2(k)) + k \cdot \ln(n)) / n$	<u>Criterion HQ(k)</u> $\min(\ln(s_u^2(k)) + 2k \cdot \ln(\log(n))) / n$
0,371708211	2755,606 468	16,05331198	16,15272661	15,8945511
0,812458212	1505,516 536	14,84430898	14,94372361	14,68554811
0,79986089	1555,258 148	14,90931996	15,00873459	14,75055909
0,844663744	1370,165 158	14,65589945	14,75531408	14,49713857

Table 2 Microsoft excel - *Decision criteria for econometric models,*

Source: Microsoft.com,2021.

2.2 SPSS

IBM SPSS Statistics software is a vast library of machine learning algorithms. It reduces pressure and risk factors. This data analysis software is user-friendly and has a modern interface with high statistics analytical capability. (IBM.com, 2021)

Innovative challenges for CRM

SPSS - silver-linear.sav [DataSet1] - IBM SPSS Statistics Data Editor

FileEditViewDataTransformAnalyzeGraphsUtilitiesExtensionsWindowHelp

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Another window of the SPSS program (Figure 2) presents the resulting econometric models of linear regression of the dependence of production on economic factors. Other regressions include power, log, and exponential. On the other hand, all econometric models explaining the impact of other factors studied on world production can be used for practical use to predict it.

SPSS - silver-linear.sav [DataSet1] - IBM SPSS Statistics Data Editor

File Edit View Data Transform Analyze Graphs Utilities Extensions Window Help

	ane	EM_LIN_Ce...	EM_LIN_C...	EM_LIN_Po...	EM_LIN_Po...	EM_LIN_HDP...	EM_LIN_HDP...	EM_LIN_kum...	EM_LIN_kum...	var
1	1.61	-3400.11	5780514.15	-38.27	1484.46	169.79	22738.39	-95.97	9210.31	
2	1.64	-1506.44	2723937.58	80.81	6529.77	966.70	822164.89	187.57	11570.47	
3	1.67	-1506.86	2582011.43	-300.20	90121.04	806.75	650841.16	-112.23	12584.92	
4	1.70	-1598.02	2553671.67	-702.82	493960.06	2.35	5.54	-367.14	134782.82	
5	1.74	-914.76	836793.41	-68.86	4741.95	96.87	9383.31	367.90	135352.21	
6	1.78	-274.25	75213.83	240.40	57791.78	190.80	35405.81	684.89	417980.89	
7	1.82	-2921.95	4088284.72	-955.59	913143.85	-1271.87	1615628.58	-540.45	292182.28	
8	1.86	-1768.52	3127647.38	-756.54	572355.19	-1879.70	3533268.72	-455.74	287782.82	
9	1.95	-1558.64	2751076.40	-761.83	580388.94	-2461.70	6059971.12	-1154.45	1332761.37	
10	1.98	-577.67	333697.21	-270.38	73707.05	-581.50	338145.41	-582.78	339633.18	
11	1.01	-929.62	864185.47	218.77	47859.61	-651.85	424580.99	-85.37	7287.34	
12	1.06	-4824.78	21388548.64	-293.99	86429.82	-2040.41	4163254.45	-831.83	690617.12	
13	1.10	-2631.04	6922481.47	191.65	36731.21	-1210.90	1466274.50	-430.37	185219.49	
14	1.12	1555.00	2449217.39	2076.77	4312130.45	929.66	864276.58	1532.19	2347597.68	
15	1.14	3842.73	14786602.28	2961.75	7984936.27	1781.72	3174541.83	2225.61	4953353.50	

Figure 2 SPSS window, Source: Ibm.com,2021.

3 Conclusion

The article clarified the econometric modeling of the dependence of production on economic factors. The article will have several benefits. The first is the contribution to science, when econometric models of selected mineral raw materials that have not yet been developed will be created and will be a model for the processing of other mineral raw materials. Another is the practical benefit, when the developed econometric models will be possible for company managers to use in strategic management. The results of the work can be used for creating industrial policy proposals, monitoring the state and performance of individual mineral resources.

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Evaluation of the utilization of Facebook by major Czech media outlets

Lukáš Malec¹, Antonín Pavlíček²

Abstract. The importance of social networking sites as sources of information has led to news media creating new channels on these platforms to connect with readers by publishing news stories and links to articles. These Facebook pages allow readers to engage with the content by commenting, sharing, or liking posts. This study analyzed 8 popular Czech online media outlets, including Aktuálně.cz, Blesk.cz, iDnes.cz, ČT24, Novinky.cz, PrimaFTV, Seznam Zprávy, and TN.cz, and their engagement on official Facebook pages. By scraping data from the Facebook pages of the selected media, we collected 16,725 comments under 479 posts and segmented readers based on their sex, location, and age. The study also provides insight into Czech media on Facebook and includes visualizations.

Keywords: Facebook, Czech Media, Segmentation, Analysis.

JEL Classification: D83

1. Introduction

Media and publishing houses have a unique opportunity to use social media platforms like Facebook to connect with their audiences and promote their content. Facebook is one of the most widely used social media platforms, with over 2 billion monthly active users, making it a valuable tool for media and publishing companies to reach a large audience. In this paper, we will discuss the ways in which media and publishing houses can use Facebook and other social media to engage with their audiences, promote their content, and build their brand.

One of the most effective ways for media and publishing houses to use Facebook is to create a dedicated page for their brand or publication. This allows them to share updates, news, and articles with their followers, as well as interact with them through comments and direct messages. This can be a great way for media and publishing companies to build a community of

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readers who are engaged with their content and can help to spread the word about their brand.

Social media platforms like Facebook also offer the opportunity for media and publishing houses to create and share video content. Video content is becoming increasingly popular, and Facebook allows users to upload and share videos directly on the platform. This can be a great way for media and publishing companies to showcase their content, build their brand, and engage with their audiences. For example, a news channel can use Facebook Live to broadcast a breaking news event or a publisher can use Facebook to share an author interview.

Another effective way for these media organizations to use social media is through content marketing. By creating and sharing high-quality, relevant content on social media, media and publishing houses can attract new readers and viewers, as well as build relationships with existing ones.

Facebook also offers a range of analytics tools that can help media and publishing houses to track the performance of their content on the platform. These tools can provide valuable insights into which types of content are resonating with audiences, how often users are engaging with their content, and which demographics are most active on their pages. This can help media and publishing companies to optimize their content and social media strategies.

Social media platforms like Facebook also allow media and publishing houses to collaborate with influencers and other brands. Influencers are individuals or groups with a large following on social media platforms, and they can be a great way for media and publishing companies to reach new audiences. For example, a publisher can collaborate with an influencer to create sponsored content that promotes a new book, or a news channel can collaborate with an influencer to create a video series.

Our approach

The primary objective of this research is to examine the online reader base of eight selected Czech media outlets by analyzing the comments on their Facebook posts. The main outcomes of this research paper include a segmentation of the reader base across multiple media outlets on Facebook, a description of each media outlet's reader segment, and visual aids for support.

Additionally, this research will address 12 hypotheses created based on common stereotypes, prejudices, and the current pandemic situation. The paper is divided into four chapters, with the first chapter being theoretical, and focused on the role of Facebook as a source of news and information in the Czech Republic and globally. The second chapter includes descriptions of the eight selected Czech online media and their Facebook accounts. The third chapter is divided into two parts, the first part is focused on the overall findings and statistics across all the selected media and the second part provides detailed dashboards of each medium. Lastly, chapter four will evaluate the twelve hypotheses and determine whether they are supported by the data.

Our research included a search for studies and theses using keywords such as Czech media, news, internet news servers, internet news, social media, news on social media, and others. We identified eight studies related to our work. The first study is a final thesis called "Konstrukce účastníků politické komunikace v českých internetových periodikách" which analyzed two Czech events from 2008 - the Prague culture grant case and the signing of the framework agreement on the American radar on the territory of the Czech Republic case (Nejedlá, 2010). The next thesis is called "Analýza nejlépe hodnocených příspěvků v diskuzích na českých internetových zpravodajských serverech" and analyzed three Czech news online servers - idnes.cz, novinky.cz, and aktualne.cz. The top-rated comment was chosen and analyzed for vulgarism, irony, humor, or disagreement with the article (Šponer, 2017). Another study is "Online žurnalistika a zpravodajské servery v ČR" which deals with current trends of online journalism and their potential on news servers in the Czech Republic (Ireimová, 2009). "Social Media References in Newspapers: Facebook, Twitter and YouTube as sources in newspaper journalism" is a content analysis that aims to examine the different appearances and functions of social media references in the news (Paulusse & Harder, 2014). "Will Social Media Save Newspapers?" found a positive relationship among newspapers' Facebook, Twitter, Web, and print readerships, but social media subscribers continue to represent a small fraction of print and Web users (Ju et al., 2014). "MEDIA PROJEKT: 1. čtvrtletí 2020 a 2. Unie vydavatelů" focuses on Czech printed newspapers and their popularity field (Unie vydavatelů, 2020). "Digital News Report 2018" by Reuters Institute and Oxford University examines the problems

with fake news and the connection between media and politicians (Reuters Institute for the Study of Journalism, 2018). Lastly, "Americans Are Wary of the Role Social Media Sites Play in Delivering the News" by Pew Research Center from 2019 (Shearer & Grieco, 2019) was also considered.

2. Methodology

This research paper utilizes the Reuters Digital News Report 2018 to identify the most popular Czech online media. The 16 selected media are Seznam.cz, iDnes.cz, Aktuálně.cz, Novinky.cz, Czech Television news online, TN.cz, iPrima.cz, Blesk.cz, Denik.cz, Super.cz, iHned.cz, Lidovky.cz, Reflex.cz, DVTV.cz, Tyden.cz, and iRozhlas.cz (Reuters Institute for the Study of Journalism, 2018). Since the focus of this research is on media engagement on Facebook, we compared the Reuters results with the following of 8 chosen media on Facebook.

The eight selected media are based on their background, readership, and Facebook profiles (Aktuálně.cz, 2020; Aust, 2016; CNCenter.cz, 2020; Economia, 2020; Facebook.com, 2020; Forbes, 2020; iDnes, 2020; iPrima, 2020; Kurzy.cz - archived, 2014; Lidovky.cz, 2016; Lupa, 2012; Lupa.cz, 2005, 2008; Mafra, 2020; NetMonitor, 2020, 2020; Novinky.cz, 2007; Novinky.cz autori, 2020; Reuters Institute for the Study of Journalism, 2018; Seznam.Cz Spouští Vlastní Televizi. Vysílat Bude Od Pátku v Multiplexu ČRa, 2018; SeznamZprávy, 2016; TN.cz, 2020; Unger, 2019; Wikipedia, 2020; Wikipedie, 2020; Zive.cz, 2009). Specifically, these media are Seznam zprávy, iDNES.cz, Aktuálně.cz, Novinky.cz, Blesk, ČT24, Prima FTV, and TN.cz.

Based on the Reuters report, the most followed medium online is Seznam.cz/zprávy, while the Seznam Zprávy Facebook page has the lowest number of likes and followers. However, ČT24 has the most followers and likes on Facebook out of all 8 media, but it is only in fifth place in terms of web portal following. This discrepancy is likely due to the fact that social networks are more popular among younger people who may be interested in various media outlets.

3. Results

To begin, we conducted an overall summary of all the chosen media, as shown in Figure 1. We collected 14,888 comments from 9,285 unique commentators. In terms of distribution of posts among the media, iDnes.cz and Prima FTV had the most posts with 71 and 70, respectively, while ČT24 had the least with only 20 posts. However, as we will see in later graphs, this does not necessarily mean that the ČT24 Facebook group is less active.

The gender segmentation revealed that men comment more than women, but the difference is not significant. When we looked at the location of the commentators, we found that the majority were from Prague, as it is the capital city of the Czech Republic, followed by the Jihočeský region, and the least active region was Plzeňský.

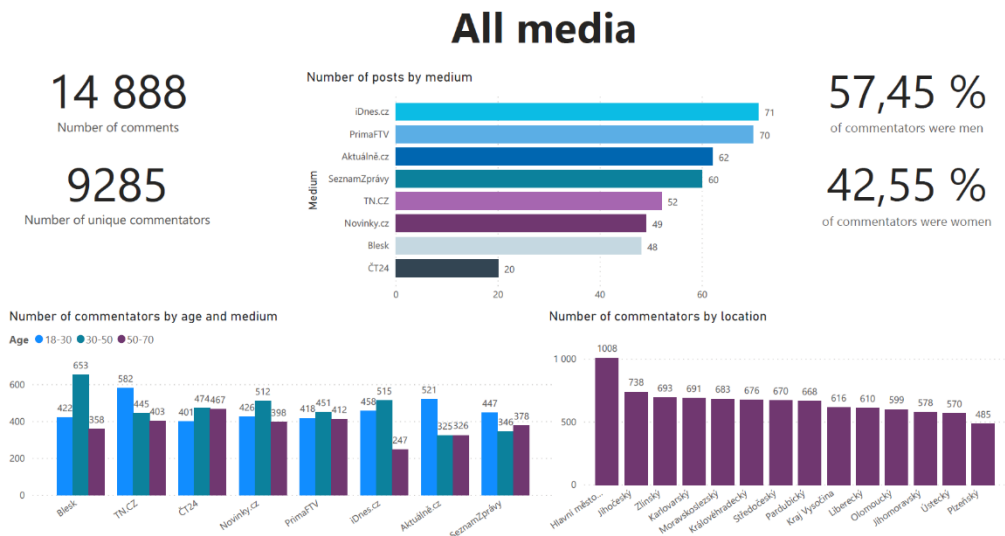


Figure 1 All media (Source: authors)

We also examined the age segmentation across the media, which provided some interesting results – in the following text we are presenting major 5 findings:

Finding 1: ČT24 has in average the most comments under 1 post, iDnes.cz or PrimaFTV have in average the least comments under 1 post.

Through the unification of the data across media, we found that ČT24 has the highest average number of comments per post (93), while iDnes and Prima FTV have the lowest average number of comments per post (26, 27) as

depicted on Figure 2. Figure 3 summarizes the average number of comments per post by medium. The high engagement on ČT24 is not surprising due to its high following on its Facebook page. However, it is surprising that iDnes and Prima FTV have the lowest results when they rank 3rd and 4th in terms of likes and followers.

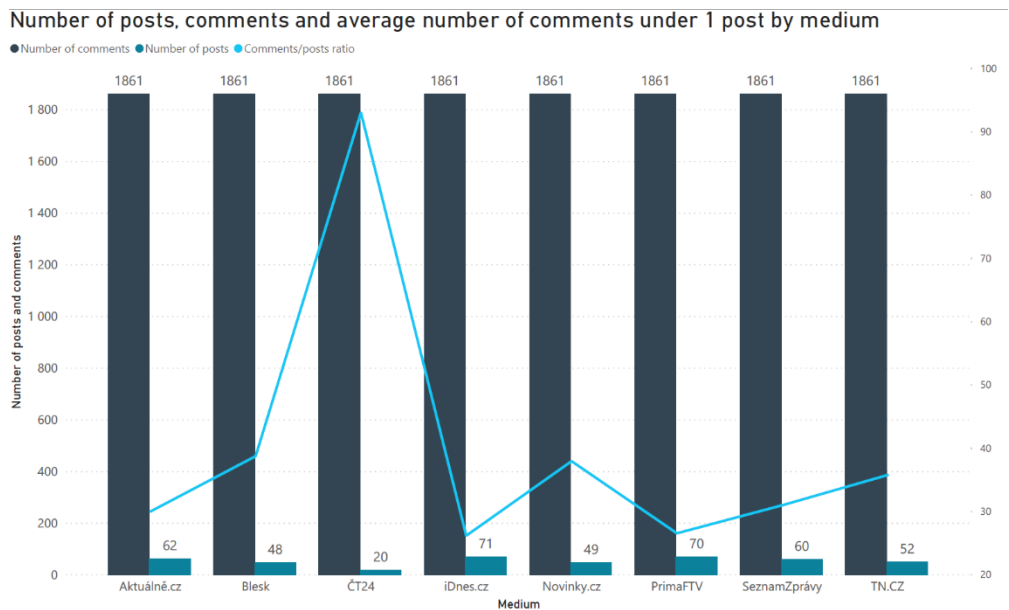


Figure 2 Number of posts, comments and average number of comments under 1 post by medium (Source: authors)

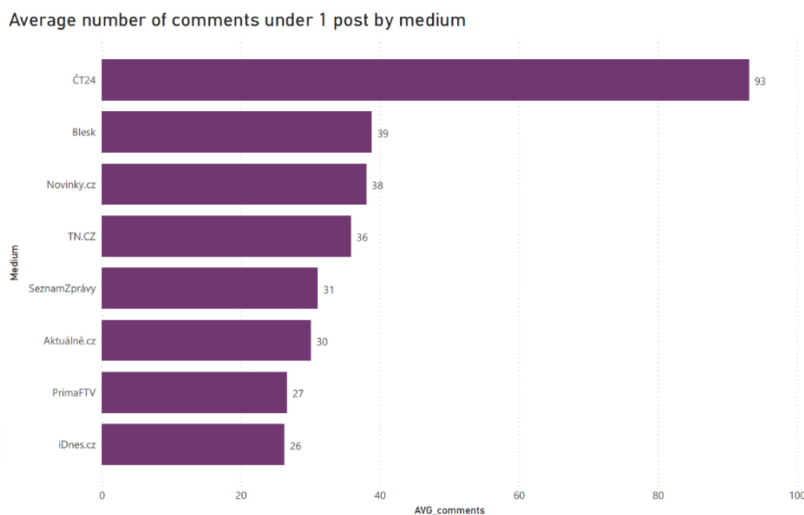


Figure 3 Average number of comments under 1 post by medium (Source: authors)

Finding 2.: Seznam Zprávy and Aktuálně.cz have slightly more regular commentators, TN.cz and Blesk have fewer regular commentators.

Another interesting discovery is that Seznam Zprávy and Aktuálně.cz have more "dedicated commentators". On average, one Seznam Zprávy commentator writes 1.6 comments, whereas one Blesk commentator writes only 1.3 comments on average. These detailed results can be seen in the following figure, which illustrates the average number of comments written by one commentator across media.

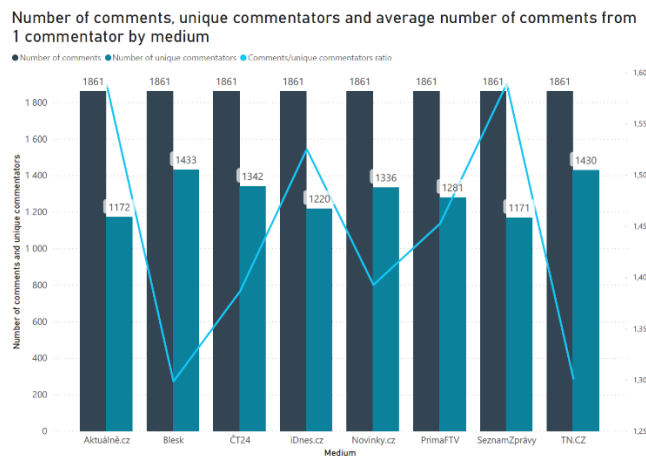


Figure 4 Number of comments, unique commentators, and average number of comments from 1 commentator by medium (Source: authors)

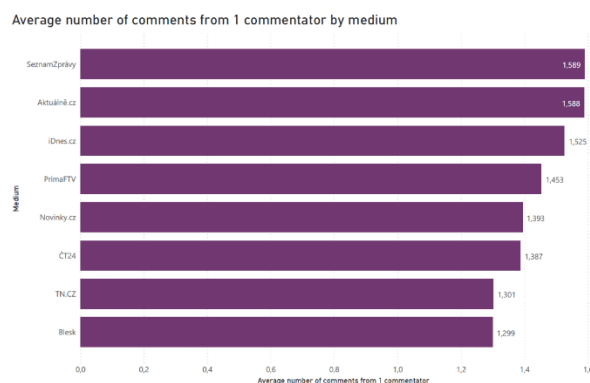


Figure 5 Average number of comments from 1 commentator by medium (Source: authors)

Finding 3.: Women comment more on TN.cz and Blesk, men comment more on iDnes.cz and Aktuálně.cz

We compared proportion of sex across media and found out that Blesk and TN.cz are read mostly by women. We suppose these results are due to fact

that women are more inclined to discuss the problem and Blesk is tabloid and TN.cz in somewhere between tabloid and news. On the other hand, mostly men read iDnes.cz and Aktuálně.cz uploading posts about local and foreign news, politics etc. Results can be seen on Figure 6.

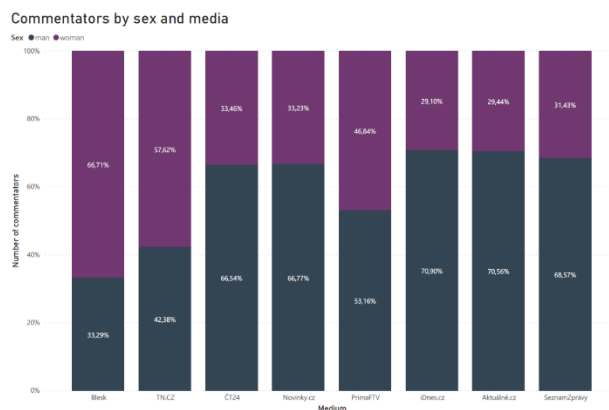


Figure 6 Commentators by sex and media (Source: author)

Finding 4.: Blesk and iDnes are have more middle age readers, Aktuálně.cz, Seznam Zprávy and TN are more popular among younger readers.

As we can see on Figure 7, the distribution of readers in different age groups is pretty even across the media. Only interesting findings are that Blesk and iDnes are read more by people in their middle age and Aktuálně, Seznam or TN are more popular among younger readers.

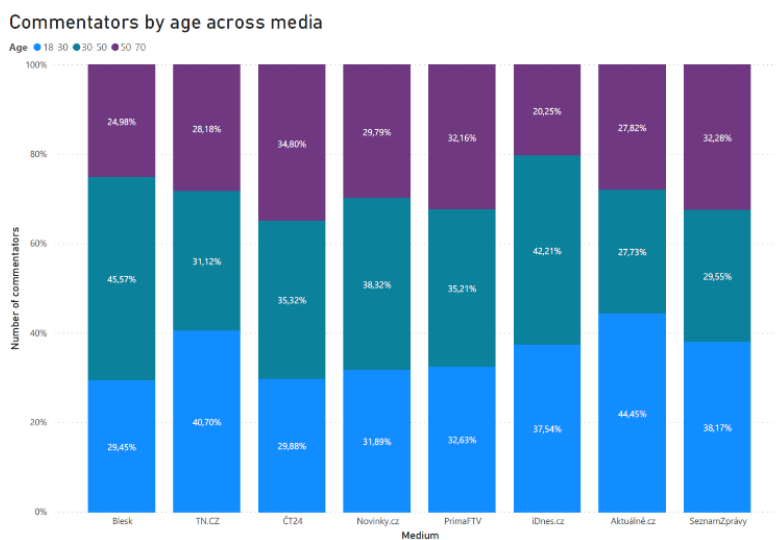
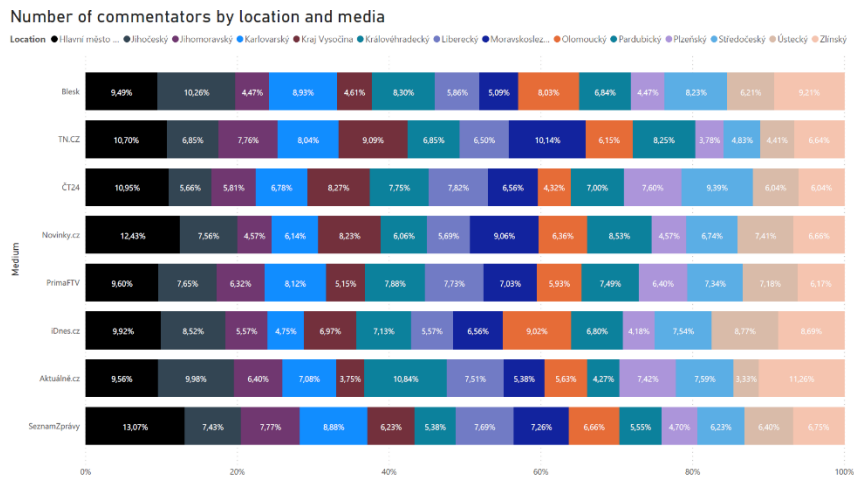


Figure 7 Commentators by age across media (Source: author)

Finding 5.: Blesk have the most readers from Jihočeský region, Prague comments largely on Seznam Zprávy.

On Figure 8 we can see the distribution of commentators across media by location. Distribution is not that surprising, interesting is that commentators from Jihočeský region read Blesk more than any other medium, Prague comments mostly on Seznam Zprávy or Novinky.cz or TN.cz is popular in Moravskoslezský Region.

**Figure 8** Number of commentators by location and media (Source: authors)

Segmentation

The segmentation in this paper was conducted on eight media. The following are the results of the segmentation:

- Seznam Zprávy has a majority of male commentators (68.57%) in the youngest age group (18-30) who are from the capital city, Prague. Seznam Zprávy is a relatively new medium created in May 2016, so we can expect a bigger expansion and more readers and followers on social media.
- IDnes.cz also has a majority of male commentators (70.9%), but the biggest age category is the middle-aged group (30-50) from Prague. Interestingly, they have very few commentators in the oldest age group, despite being owned by the Czech prime minister who is voted for mostly by older people.

- Aktuálně.cz, created around the same time as iDnes.cz, has fewer posts and fewer commentators. The segmentation here is mostly men (70.56%). Most commentators are young people from 18 to 30 (521 commentators) and are mostly from the Zlínský region, not Prague as one might expect based on the size of these regions.
- Novinky.cz has a similar segmentation to iDnes.cz. Most commentators are men (66.77%), in the middle-aged group (30-50) from the capital city, Prague. The Novinky.cz Facebook page was also created in 2009, a few months after iDnes.cz and, despite having fewer posts, has more unique commentators than iDnes.cz.
- The ČT24 Facebook page, also created in 2009, has only 20 posts but an impressive number of 1,342 commentators for such a small number of posts. Most of these commentators are men (66.54%). In terms of location, the majority of commentators are from Prague.
- The TN.cz Facebook page has more female commentators (57.62%), which is not as dominant as other media with a majority of male commentators, but it is still a significant amount. We can assume this may be due to the content TN.cz posts, but this page has similar posts to other media. TN.cz also has a lot of commentators, mostly young people from Prague.
- Zpravodajství FTV Prima or Prima News has a majority of male commentators (53.16%) from Prague. The age groups are relatively balanced, with a slightly larger number of middle-aged individuals. FTV Prima has a lot of posts, but the number of commentators is not as significant compared to other media.
- Blesk.cz is a medium that is mostly commented on by women (66.71%). This can be attributed to the fact that women are more prone to discuss the issue, and Blesk.cz is a tabloid that posts local and foreign news about politics, economics, and celebrity.

4. Conclusion

In conclusion, media and publishing houses have a wide range of opportunities to use Facebook and other social media platforms to engage with their audiences, promote their content, and build their brand. From

creating dedicated pages and using advertising features to creating and sharing video content, engaging with audiences through groups, and collaborating with influencers, social media can be a powerful tool for media and publishing companies to reach new audiences and promote their content. However, it is important to note that social media strategies should be tailored to the specific needs and goals of the media and publishing house, and should be regularly evaluated and optimized to ensure they are effective.

Acknowledgements

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Forecasting of economic quantities using fuzzy autoregressive model and fuzzy neural network

Dušan Marček¹

Abstract. Most models for the time series of stock prices have centered on autoregressive (AR) processes. Traditionally, fundamental Box-Jenkins analysis have been the mainstream methodology used to develop time series models. Next, we briefly describe the develop a classical AR model for stock price forecasting. Then a fuzzy regression model is then introduced. Following this description, an artificial fuzzy neural network based on B-spline membership function is presented as an alternative to the stock prediction method based on AR models. Finally, we present our preliminary results and some further experiments that we performed.

Keywords: Time series models, SVR, ECM, co-integration, learning algorithms, kernel function.

JEL Classification: C13, G32.

1 Introduction

In Marcek (1998) the stock price autoregressive (AR) models based on the Box and Jenkins (1976) methodology were described. Although an AR model can reflect well the reality, these models are not suitable for situations where the quantities are not functionally related. In economics, finance and so on, there are however many situations where we must deal with uncertainties in a manner like humans, one may incorporate the concept of fuzzy sets into the statistical models. The fuzzy regression is another efficient approach for computing the parameter of the structure for an uncertain situation and for predicting of uncertain events following the decision.

The fuzzy regression models have been in use in analyses for many years. Lots of issues of journal Fuzzy Sets and Systems as well as many others have been articles, whose analyses are based on the fuzzy regression models. From reviewing of these papers, it becomes clear that in economic applications the use of method is not on the same level as analyses using classical linear regression. Computers play an important role in fuzzy regression analyses and forecasting systems. The widespread use of the method is influenced by

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inclusion of fuzzy regression routines in major computer software packages and selection of appropriate forecasting procedure.

The primary objective of this paper is a focused introduction to the fuzzy regression model and its application to the analyses and forecasting from classical regression model of view. In Section 2, we briefly describe some basic notions of fuzzy linear regression. Following this description, we present evaluation of fuzzy linear regression model in the context of a practical application in comparison to the AR model presented in Marcek (1998). In this paper we primarily concern with short-term forecasting, say one period in the future. The data set used in this paper (163 observations, stock price) is available, and is depicted in Marcek (1998). To build a forecast model we have defined the sample period for analysis y_1, \dots, y_{128} , i.e. the period over which we will be building or estimating the forecasting model and the ex post forecast period (validation data set), y_{129}, \dots, y_{163} as the time period from the first observation after the end of the sample period to the most recent observation. In order to study the regularities of this process, the observed time series is viewed as a realization of a stochastic process. To simplify our notes, we suppose that the times at which the observations are recorded are regularly spaced, which allows us to consider an index by taking only integer values. The process is denoted by, where the index set is A for analysis data set or E for ex post forecast data set.

2 AR Modelling

We give an example that illustrates one kind of possible results. We will regard these results as the referential values for the approach of fuzzy autoregressive and ANN modelling.

To illustrate the Box-Jenkins methodology, consider 163 values of the stock price time readings of a typical company (say VAHOSTAV company, see Figure 1). To build a forecast model the sample period for analysis y_1, \dots, y_{128} was defined, i.e. the period over which the forecasting model was developed and the ex post forecast period (validation data set), y_{129}, \dots, y_{163} .

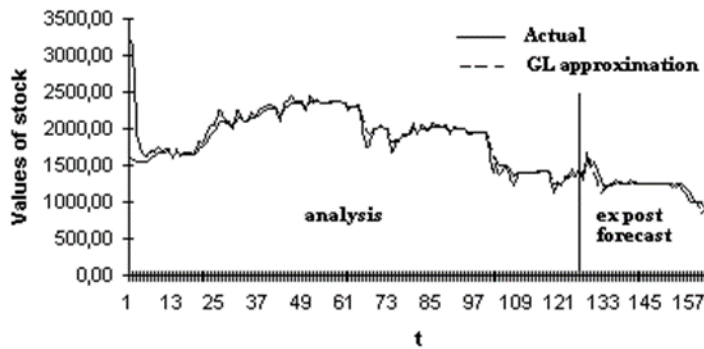


Figure 1 The data for VAHOSTAV stock prices (January 1997 - August 1997) and the values of the AR(7) model for VAHOSTAV stock prices estimated by GL algorithm

After some experimentation, we have identified two models for this series (see Box and Jenkins (1976)): the first one (1) based on Box-Jenkins methodology and the second one (2) based on signal processing.

$$y_t = \xi + a_1 y_{t-1} + a_2 y_{t-2} + \varepsilon_t \quad t = 1, 2, \dots, N-2 \quad (1)$$

$$y_t = -\sum_{k=1}^7 a_k y_{t-k} + \varepsilon_t \quad t = 1, 2, \dots, N-7 \quad (2)$$

The final estimates of model parameters (1), (2) are obtained using OLS (Ordinary Last Square) and two adaptive filtering algorithms in signal processing Bayhan (1997). The Gradient Lattice (GL) adaptive algorithm and Last Squares Lattice (LSL) algorithm representing the parameter estimates of the predictors (1), (2) were used. In Tab. 1 the parameter estimates for model (2) and corresponding RMSE's are given. Fig. 1 shows the GL prediction results and actual values for stock price time series in both analysis and ex post forecast period.

Table 1 The parameter estimates for model (2) and corresponding RMSE's

Model	Order	Est. proc	\hat{a}_1	\hat{a}_2	\hat{a}_3	\hat{a}_4	\hat{a}_5	\hat{a}_6	\hat{a}_7	RMSE*
(1)	2	OLS	1.113	-0.127	$\xi = 26.639$					67.758
(2)	7	GL	-0.751	-0.170	-0.0230	-0.0128	-0.0028	-0.0472	0.0084	68.540
(2)	7	LSL	-0.8941	-0.6672	0.7346	-0.2383	0.1805	-0.5692	0.4470	94.570

*ex post forecast period

3 Fuzzy Autoregressive (FAR) Modelling

Next, we examine the application of fuzzy linear regression model (Takagi & Sugeno, 1985)] to the stock price time readings used in (1) and (2). Recall that the models in (1) and (2) fit to the stock prices were the AR (2) and AR (7) processes. In the fuzzy regression model proposed by Tanaka, Uejima, Asai (1982), the parameters are the fuzzy numbers. The regression function of such the fuzzy parameters can be modeled by the following equation

$$Y_t = A_0 * \varphi_0(x_{0t}) \oplus A_1 * \varphi_1(x_{1t}) \oplus \dots \oplus A_k * \varphi_k(x_{kt}) = \mathbf{A}^T \mathbf{x}_t \quad (3)$$

where A_0, A_1, \dots, A_k are fuzzy numbers, \oplus and $*$ are fuzzy addition and fuzzy multiplication operators respectively, Y_t is fuzzy subset of y_t . This kind of fuzzy modelling is known as fuzzy parameter extension.

The problem to find out fuzzy parameters gives the following linear programming solution

$$\begin{aligned} \min \quad & s = c_0 + c_1 + \dots + c_k \\ \text{subject to} \quad & c_j \geq 0 \end{aligned}$$

and

$$\begin{aligned} (h-1)\mathbf{c}'|\mathbf{x}| - (y_t - \mathbf{x}'\alpha) &\geq 0 \\ (1-h)\mathbf{c}'|\mathbf{x}| - (y_t - \mathbf{x}'\alpha) &\geq 0 \end{aligned} \quad (4)$$

for $t = 1, 2, \dots, N$

where $c_j, j = 0, 1, \dots, k$ is the width or spread around the center of the fuzzy number, $\alpha = (\alpha_0, \alpha_1, \dots, \alpha_k)$ denotes vector of center of the fuzzy numbers for model parameters, $\mathbf{x} = (x_0, x_1, \dots, x_k)$ denotes vector of regressor variables in (3), h is an imposed threshold $h \in [0, 1]$ (see Savic and Pedricz, 1991). A choice of the h value influences the widths c_j of the fuzzy parameters. The h value expresses a measure of the fitting of the estimated fuzzy model (3) to the given data. The fuzziness of $\mathbf{c}' = (c_0, c_1, \dots, c_k)$ of the parameters $\tilde{x}_0, \dots, \tilde{x}_k$ for the models (1) and (2) are given in Tab. 2.

The forecast for future observation is generated successively through the Eq. (3) by replacing the functions of the independent variables ($\varphi_j(x_{jt}), j = 0, 1,$

..., k by observations y_{t-j} . Then the forecasting function of the fuzzy AR process is

Table 2 The fuzziness of parameters $\tilde{x}_0, \tilde{x}_1, \dots, \tilde{x}_k$ for the model (4)

$h=0.5 \quad \tilde{A}_k \quad k:$	0	1	2	3	4	5	6	7
Model AR(2)								
Modal values (α)	26.639	1.113	-0.127					
Spread (c)	0	0	0.229					
Model AR(7)								
Modal values (α)	45.930	1.085	0.086	-0.253	0.084	-0.006	0.208	-0.228
Spread (c)	0	0	0	0	0.209	0	0	0

$$Y_{T+1}(T) = A_0 \oplus A_1 * y_T \oplus A_2 * y_{T-1} \oplus \dots \oplus A_k * y_{T-k+1} \quad (5)$$

where $Y_{T+1}(T)$ is the forecast for period $T+1$ made at origin T . We observe that the forecasting procedure (5) produces forecast for one period ahead. As a new observation becomes available, we may set the new current period $T+1$ equal to T and compute the next forecast again according to (5)

4 B-Spline Neural Network Approach

The concept of fuzzy neural network (FNN) can be approached from several different avenues. The one that we have used for stock price forecasts is shown in Fig. 2. This figure shows the FNN with input neurons (input layer), a single hidden layer with p processing units (fuzzy neurons) and one output unit.

Input selection is of crucial importance to the successful development of FNN models. In models (1) and (2) potential inputs were chosen based on traditional statistical analysis: these included the raw stock price series and lags thereof. The relevant lag structure of potential inputs was analyzed using traditional statistical tools: ACF, PACF and the MSE criterion. All the above techniques are in reality series yet contain relatively few parameters, the theoretical ACF was estimated by the sample ACF, etc.). In fact, we obtain a certain number of input values, but we are sure that these values are one of many other possible values. Thus, we will further suppose that the potential inputs, which were chosen based on statistical analysis, are fuzzy numbers characterized by a membership functions (the uncertainty is modeled as a possibility distribution) belonging to a class of bell-shaped functions.

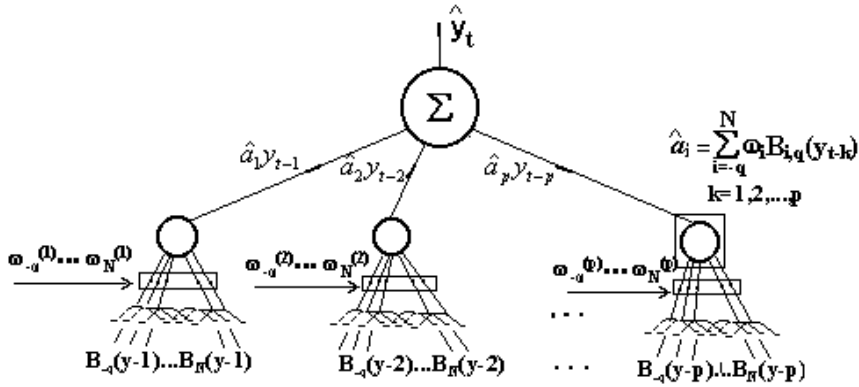


Figure 2 The neural fuzzy system architecture

Inputs to the fuzzy neuron in hidden layer are fuzzy numbers denoted $B_{j,k,t}$, $j = 1, 2, \dots, p$. k identifies the order of the B-spline basis functions. They express the neural input signals in terms of their membership functions based on B-spline basis functions of the data. This concept is often called by Wu and Harris (1996) as B-spline FNN.

Now, let us suppose that the system has $\mathbf{B}_{j,k,t}^T = [B_{1,k,t}, B_{2,k,t}, \dots, B_{p,k,t}]$ as inputs and $\mathbf{y}^T = [y_1, y_2, \dots]$ as outputs. Then the information set ψ describing process behavior may be written in the form

$$\psi = \{(B_{1,k,t}, B_{2,k,t}, \dots, B_{p,k,t}, y_t) : t \in T\} \quad (6)$$

Each the j -th input neuron distribute the inputs to the j -th neuron in the hidden layer. Neural input signals are then weighted by weights denoted $\omega_{j,t}$. In general, the weights are in the range of $(0, 1)$. Each processing unit performs internal operations on these neural inputs and computes the neural output signal \hat{a}_j . The internal operations are based on aggregation, i.e., the sum of the products of weights and inputs, and its transformation into the neural output \hat{a}_j . These two internal operations for j -th neuron in the hidden layer are defined as

$$U_j = \sum_{t \in A} \omega_{j,t} B_{j,k,t} \quad (7)$$

for aggregation, where U_j is a measure similarity between the inputs and weights, and

$$\hat{a}_j = f(U_j) \quad (8)$$

for transformation operation, where f is the type of transfer function. We set this function to the identity, that is, $f(U_j) = U_j$.

The neuron in the output layer provides simply the computation of Eqs. (1), (2) and produces output signal \hat{y}_t .

The learning algorithm is based on error signal. The neural network modifies the weights $\omega_{j,t}$ in synaptic connections with respect to the desired fuzzy system output y_t .

The second learning scheme uses the first-order gradient procedure. In our case, the subjects of learning are the weights $v_{j,t}$ only. These weights can be adapted by the error back-propagation algorithm. In this case, the weight update is particularly simple. If the estimated output for the single output neuron is \hat{y}_t , and the correct output should be y_t , then the error e_t is given by $e_t = y_t - \hat{y}_t$ and the learning rule has the form

$$\omega_j(y_{t-j}) \leftarrow \omega_j(y_{t-j}) + \eta, \quad j = 1, 2, \dots, p$$

where $\Delta e_t = \frac{B_{j,k}(y_{t-j})e_{t,j}}{C + [(B_{1,k}y_{t-1}^2 + \dots + B_{p,k}y_{t-p}^2)(y_{t-1}^2 + \dots + y_{t-p}^2)]}$ for $j=1, 2, \dots, p$, $t \in A$ and

$$e_{t,j} = \frac{y_{t-j}e_t}{y_{t-1}^2 + \dots + y_{t-p}^2} \quad \text{for } j=1, 2, \dots, p, t \in A.$$

The term, $\eta \in (0,1)$ is a constant called the learning rate parameter,

The error of the fuzzy system, i.e., the difference between the fuzzy system forecast \hat{y}_t and the actual value y_t is analyzed through the RMSE. Let \hat{y}_t be a linear function

$$\frac{B_{j,k}(y_{t-j})e_{t,j}}{C + [(B_{1,k}y_{t-1}^2 + \dots + B_{p,k}y_{t-p}^2)(y_{t-1}^2 + \dots + y_{t-p}^2)]} = \sum_{j=1}^p \sum_{t \in A} \omega_{j,t} B_{j,k,t} y_{t-j} \quad (9)$$

such that

$$\sum_{t \in T} (y_t - \hat{y}_t)^2 \leq \sum_{t \in T} [y(\mathbf{z}'_t - \hat{y}_t)]^2 \quad (10)$$

for any other linear function $y(\mathbf{z}'_t)$. It is clear that such function can be derived by using the Normalized Back-Propagation (NBP) algorithm which minimizes the term of the left-hand side of the relation (10) by adjusting the

weights $\omega_{j,t}$ in Eq. (9). The proof of the convergence of the NBP algorithm can be found in Polycarpou and Ioannou (1992).

The measure of similarity (7) may be defined as the inner product of vectors $\mathbf{B}_{j,k}(y_{t-j})$ and $\omega_{t-j}(j)$, that is

$$U_j = \omega_{t-j}^T(j) \mathbf{B}_{j,k}(y_{t-j}) \quad (11)$$

where : $\omega_{t-j}^T(j) = [\omega_{t-j}(j), \omega_{t-j+1}(j), \dots, \omega_{t-j+n}(j)]$ is an $1 \times n$ row vector of the weights and $\mathbf{B}_{j,k}^T(y_{t-j}) = [B_{j,k}(y_{t-j}), B_{j,k}(y_{t-j+1}), \dots, B_{j,k}(y_{t-j+n})]$ is an $1 \times n$ row vector of the B-spline functions.

Next, we show that the B-spline neural network may be considered as a fuzzy linear controller. We now define the vectors as follows:

Let \mathbf{z}_j^T be an $1 \times n$ row vector of the regressor variables

$$\mathbf{z}_j^T = [y_{t-j}, y_{t-j+1}, \dots, y_{t-j+n}] \quad j = 1, 2, \dots, p$$

\mathbf{y}^T be an $1 \times n$ row vector of the observations

$$\mathbf{y}^T = [y_1, y_2, \dots, y_n]$$

and

$\hat{\mathbf{a}}^T$ be an $1 \times p$ row vector of the parameters

$$\hat{\mathbf{a}}^T = [\hat{a}_1, \hat{a}_1, \dots, \hat{a}_p]$$

Then the concept of B-spline FNN may be also considered as a $\hat{y}_t = \hat{\mathbf{a}}^T \mathbf{z}_j$ is well known by Sugeno and Takagi (1985) linear fuzzy controller which (in our notation) has the following form

$$R = \text{if } U_1 = \hat{a}_1 \text{ and } U_2 = \hat{a}_2 \text{ and } \dots \text{ and } U_p = \hat{a}_p$$

$$\text{then } \hat{y}_t = \hat{\mathbf{a}}^T \mathbf{z}_j, \quad t = 1, 2, \dots, n$$

where the fuzzy linear control rules R has been derived by neural network purely from the database describing previous or next behavior of the system.

5 Empirical Results

The network described in Section 3 was trained in software at the Faculty of Management Science and Informatics Zilina. The statistical forecast accuracy of the FNN according to Fig. 2 depends on the type of transfer function in Eq. (8) and the formulation of the B-spline curve in Eq.

(6). The approximation is better the higher the value of k . All B-spline basis functions are cubic ones. Assume that the mesh points of B-spline basis function is x_i , $i = 1, 2, 3, 4$. Then the cubic B-spline basis functions ($k = 3$) for $i = 1$ have the form as follows

$$\begin{aligned}
 B_{i,3}(y_{t-j}) &= \frac{y_{t-j} - x_i}{x_{i+3} - x_i} \frac{(y_{t-j} - x_i)^2}{(x_{i+2} - x_i)(x_{i+1} - x_i)} \quad \text{for } y_{t-j} \in (x_i, x_{i+1}) \\
 B_{i,3}(y_{t-j}) &= \frac{(y_{t-j} - x_i)}{x_{i+3} - x_i} \left[\frac{(y_{t-j} - x_i)(x_{i+2} - y_{t-j})}{(x_{i+2} - x_i)(x_{i+2} - x_{i+1})} + \frac{(y_{t-j} - x_{i+1})(x_{i+3} - y_{t-j})}{(x_{i+3} - x_{i+1})(x_{i+2} - x_{i+1})} \right] + \\
 &\quad + \frac{(x_{i+4} - y_{t-j})}{(x_{i+4} - x_{i+1})} \left[\frac{(y_{t-j} - x_{i+1})^2}{(x_{i+3} - x_{i+1})(x_{i+2} - x_{i+1})} \right] \quad \text{for } y_{t-j} \in (x_{i+1}, x_{i+2}) \\
 B_{i,3}(y_{t-j}) &= \frac{(y_{t-j} - x_i)}{x_{i+3} - x_i} \left[\frac{(x_{i+3} - x_i)^2}{(x_{i+3} - x_{i+1})(x_{i+3} - x_{i+2})} \right] + \\
 &\quad + \frac{(x_{i+4} - x_i)}{x_{i+4} - x_{i+1}} \left[\frac{(y_{t-j} - x_{i+1})(x_{i+3} - y_{t-j})}{(x_{i+3} - x_{i+1})(x_{i+3} - x_{i+2})} + \frac{(x_{i+4} - y_{t-j})(y_{t-j} - x_{i+2})}{(x_{i+4} - x_{i+2})(x_{i+3} - x_{i+2})} \right] \\
 &\quad \text{for } y_{t-j} \in (x_{i+2}, x_{i+3}) \\
 B_{i,3}(y_{t-j}) &= \frac{(x_{i+4} - y_{t-j})}{x_{i+4} - x_{i+1}} + \left[\frac{(x_{i+4} - y_{t-j})^2}{(x_{i+4} - x_{i+2})(x_{i+4} - x_{i+3})} \right] \text{ for } y_{t-j} \in (x_{i+3}, x_{i+4}) \\
 B_{i,3}(y_{t-j}) &= 0 \quad \text{otherwise}
 \end{aligned}$$

where y_{t-j} , $j = 1, 2, \dots, p$, $t \in A$ are observations. These mesh points are given as

$$\begin{aligned}
 x_1 &= \min\{y_{t-j}\} & x_5 &= \max\{y_{t-j}\} & t &\in A \\
 x_2 &= (x_5 - x_1) / 4 + x_1 & x_3 &= 2[(x_5 - x_1) / 4] + x_1 \\
 x_4 &= 3[(x_5 - x_1) / 4] + x_1
 \end{aligned}$$

The values of B-spline functions are shown in Fig. 2.

Our FNN was trained on the training data set. Periodically, during the training period, the RMSE of the FNN were measured not only on the training set but also on the validation set. The final FNN chosen for the stock price prediction is the one with the lowest error on the validation set. Note also, the training phase was finished after 5.103 epochs, the best model being obtained after 2.3 103 epochs (see Fig. 3).

The RMSE's of our predictor models are shown in Tab. 3. From this table can be seen that the basic (non-fuzzy) artificial neural network architecture described in (Marcek, 1998) does not support its use for daily frequencies. The initial results of the FNN forecasting model are clearly better.

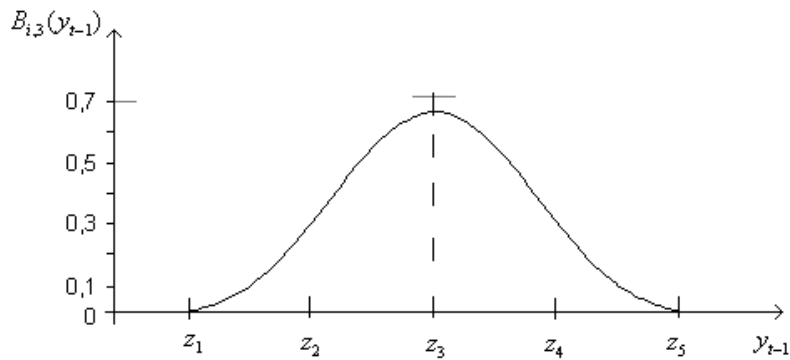


Figure 3 The plot of B-spline values

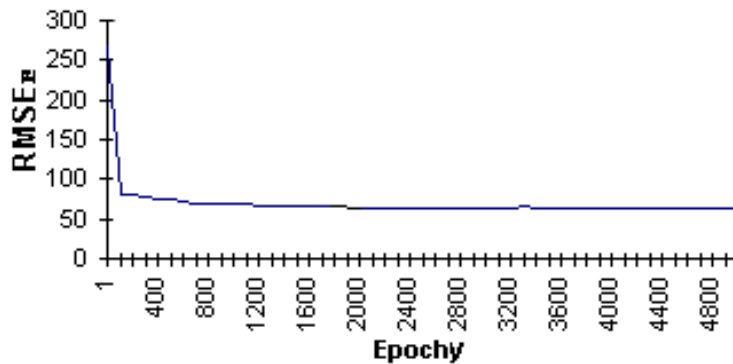


Figure 4 Epochs versus RMSE

Table 3 The RMSE's of our predictor models

Model	RMSE*
AR(2)	67.7
Basic (non fuzzy) neural network (see [6])	67.2
FNN	63.5

* Validation set

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IT innovations and their contribution to business development

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Abstract. Nowadays, innovation is a basic prerequisite for the development of an enterprise and for gaining a stable position in the competitive market. Innovation in the IT sector is fundamentally permeating all sectors of the national economy. Information technology is helping to increase the efficiency of workflow performance. The optimal combination of information technology with business process management and an appropriate corporate culture is reflected in the added value of the enterprise. The subject of the paper are enterprises operating in the IT sector in the Slovak Republic. The aim of the paper is to point out the need for the use of IT innovations and through the statistical method of multiple linear regression to point out their contribution to business development.

Keywords: innovation, innovation management, business management, motivation, information technologies.

JEL Classification: C39, M15, O32

1 Introduction

Effective corporate governance affects the ability to respond to influences from the internal and external environment. The demand for new product requirements is increasing. The role of the business is to create an offer with the customer's needs in mind. Implementing appropriate changes will increase the effectiveness of the company's quality management system. Change requires a comprehensive view of the resources, barriers, and innovation potential of the enterprise. The issue of innovation deals with the influx of new ideas to achieve the optimization of production processes, considering the quality of the final output of the innovated product. At the same time, the choice of appropriate methods of introducing innovation into business processes has an impact on the number of new proposals, models as

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well as on the exploitation of market opportunities. One of the possible methods is the upgrade of IT technologies, which contributes to the emergence of new ideas.

Loučanová - Kalamárová - Olšiaková (2016) consider innovation management as a set of activities, starting from the creation to the introduction of a product on the market. It is about the analysis, decision-making, implementation, and control of innovation processes. In their study, the authors Kádárová - Kádár - Kobulnický (2018) characterize the concept of innovation management as a system of effective management of workers, the output of which is a plan of innovation tasks. It follows that innovation management can be characterized as a process when, based on scientific knowledge and practical experience, managers carry out management activities in accordance with the innovative objectives of the enterprise. It forms a prerequisite for the emergence of new opportunities for product and service development, as well as the exploitation of financial opportunities for the growth of enterprise value.

The concept of innovation in professional, scientific domestic and foreign literature has several meanings in terms of its characterization. The first definition of innovation is found in Porter from 1990, as a process of using new knowledge, technologies to create innovative products. Synonym of the term innovation is the successful production, assimilation, and use of novelty in the economic and social sphere. Based on which the needs of an individual or society are satisfied. Hittmar - Hrnčiar - Lendel (2017) start from a review of the different definitions of the term innovation and, by common reasoning, conclude that innovation is a new specific solution to a problem for an enterprise. The result of which is the transfer of ideas into new products, processes, systems, and social relations. Managers need to understand the innovation process in terms of marketing activities, comprehensive corporate strategy, capacity, project management, staff organisation, and the selection and implementation of new products.

The innovation process is the focus of innovation management. It involves a series of three stages. The first is elaboration, discovery, creation of innovation opportunities and their solutions. Then the development and exploitation of opportunities and solutions to realise them. The last stage of the innovation process is the evaluation and selection of the best idea and its

solution (Haefner et al., 2021). The first two stages require creativity and employee motivation, which is a prerequisite for successful business management.

In view of the many definitions of innovation, different divisions of innovation classifications have emerged. In Loučanová - Parobek (2014) we find a division of innovations according to the Valent's innovation spectrum, which divides innovations into eleven stages according to the growth in importance. They complement the characterization of the different stages of innovation with a practical example. They describe innovation at minus the first stage as the destruction of original features, i.e., the object of innovation loses its functionality. A certain worn-out part of the machine is subject to innovation. In the case of a regenerative change (upgrading to zero degree), maintenance or repair of the machine is necessary, which is inevitable. The first, second and third stages of Valent's growth scale of the need for innovation are classified by the authors as process innovations. They argue that quantitative change indicates an increase in production capacity where a firm applies multiple machines of the same quality. The change in the production process guides the enterprise to better utilization of manpower, machinery. Thereby minimizing downtime. The third level of innovation is aimed at adapting the quality of all elements of the production process to a uniform level. At the same time, in this stage of innovation, the enterprise expands the specialisation of the quantity of production (e.g., application of new tools to a machine already used by the enterprise). Other innovation stages are aimed at product innovation. The new variant stage refers to the maintenance of the main role of the product, the sub-functions are subject to change. Generational change is described as an absolute change in the basic features. The last stage of product innovation is innovation aimed at generic change (extension, merging of several product features into a whole).

Competition in the IT4P field is increasing rapidly around the world. IT technology businesses are actively responding to the demands placed on it from the environment. The improvement of the economic results of enterprises is the result of a purposeful, systematic, and organized search for sources of change. The authors Drucker (2002) and Kovac (2003) specify two main areas acting on the need for introducing changes into business management. These are changes from the internal and external environment, which they complement with the types of innovation opportunities and their

specification. We have focused our attention on the sources from the external environment mentioned by them, where they include the type of innovation opportunity, “New knowledge”. These are a prerequisite for product value growth. A company with a knowledge-based team that makes effective use of its qualities and skills can introduce change into management. To implement innovations in internal company processes and to determine their impact on performance, the company needs to aggregate all the information on market performance. According to the OECD (2018), it should focus on four basic areas to assess the ability of the enterprise to implement innovation. The enterprise must assess the enterprise's general resources, general managerial capabilities, employees' skills and their performance coordination, and technological capabilities.

2 Motivation of employees

In most cases, skills, abilities, and a positive culture guarantee the growth of the added value of the company. The manager is the person who plays an important role in effectively motivating his/her work team. Whereby the appropriate method of motivation forms a unity with the expectations of the employee. Muhlfeit and Costi (2019) say that inspiration is not enough, it is only an internal pull that maintains the direction of the company for the future. They consider motivation as the pressure that is exerted on performance towards set tasks or steps leading to a goal. Motivation has a significant impact on the performance of employees and the enterprise, which is reflected in the encouragement of the workforce to perform. Saether (2019) adds to this idea and states that motivation is a significant element influencing innovation. According to Blaskova and Hitka (2011), the process of motivation in an enterprise should be continuous, deliberate, and permanent with the primary goal of creating appropriate working conditions while using effective motivational approaches, tools, measures, or events. We deduce from the findings that motivation is linked to inspiration. The harmony of these two elements creates an environment where employees are willing to invest their energy, their strengths, their resources in the performance of their work. Motivation needs to be continuously improved, strengthened, or oriented in the right direction.

Saether (2019) breaks down motivation into intrinsic, identified, and integrated. The intrinsic motivation of an employee is determined by his/her

interests, he/she acts upon it based on satisfaction and enjoyment. Identified is described as a sense of volitional behavior that is consistent with personal goals. He considers integrated as an unreliable measure of employee performance. Intrinsic motivation, such as financial reward for work done, is not sufficient according to Muhlfeit and Costi (2019). Employees' actions for the benefit of the company are influenced by their inspiration. The combination of inspiration and the right motivation guarantees the prosperity of the enterprise even in critical times. Enterprises need to focus on identified motivation to reduce the demands on intrinsic motivation.

Employees find work meaningful if their needs are met. Generally, satisfaction of lower-level needs leads to a shift to higher level needs. Maslow proposed five needs that drive human behavior, their motivation and development. He divides the needs from the lowest to the highest level by a pyramid. It is an arrangement of needs in an ijangle according to the intensity of their provision, stratification (see Figure 1).

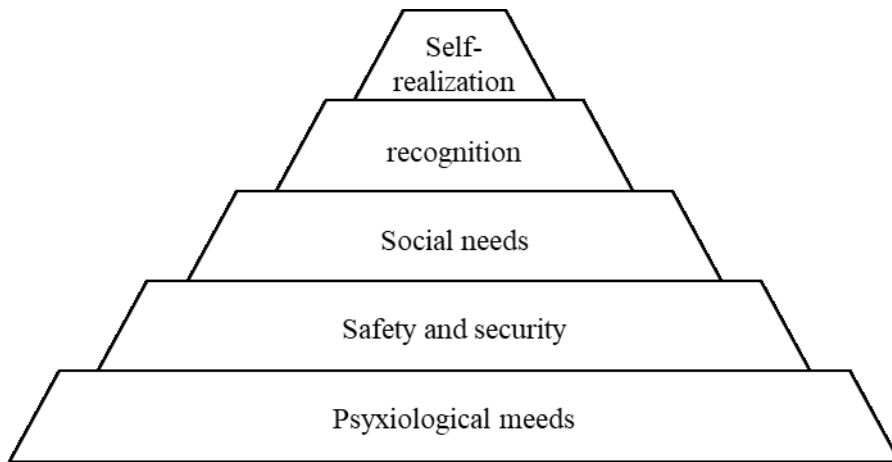


Figure 3 Maslow's hierarchy of needs. Source: Hayre-Kwan et. al. (2021).

Montag et al. (2020) state that the lower floors contain needs that are important for individual and social survival. By satisfying physiological needs, the personality is motivated to satisfy safety needs as well. This is the human need for security. Because of satisfying the lowest layers, socialization in the workplace improves, communication increases, and employees are more informed. Recognition is described as a need that affects the success of an employee's growth. They argue that if an employee, knows his/her place in the company and is identified with it, he/she highlights his/her potential for value added growth of the company.

The principle of Maslow's pyramid is growth to higher spheres provided the needs of the lower level are met. The feeling of security in employees, ensuring regular information, creating a motivating environment, and setting the right conditions for evaluation become the criteria for the success of the enterprise. Achieving which is possible if the manager is self-motivated, can understand the factors influencing motivation and finally manages the enterprise effectively.

3 Methodology and methods

In this paper we analyse data obtained from a public database of the Slovak Republic called DATAcube for the period 2008 to 2021. The subject of the study was innovation in enterprises with SK NACE Rev. 2 code. 62 Computer programming, consultancy, and related services.

To analyse the influencing factors on IT4P innovation in more detail, we used multiple linear regression. The latter helped us to understand and identify the factors that managers should consider growing the added value of the business. We used SPSS software to help us achieve a holistic view of the analysis conducted. In relation to the regression evaluation, we used Cohen's Cohen's Coefficient of Pearson's correlation, which is in the interval $<-1, 1>$.

We also paid attention to the innovation intensity of the analysed group of enterprises, i.e., the share of innovation expenditures in the revenues of innovating enterprises. Data of this type are recorded in the public database DATAcube.sk with a two-year lag. We have supplemented the evolution of innovation intensity with a linear trend line.

4 Results

Table 1 provides an overview of the input data obtained from the public database of the Statistical Office of the Slovak Republic for the period 2010 to 2021. The object of interest was to analyse the impact of the independent variables - Expenditure on research and development in thous. €, Number of employees (Average), Average staff pay in €. on the dependent variable Revenues for own performance of enterprises of group 62 according to SK NACE Rev. 2.

Table 4 Input data for multiple linear regression, Source: own processing by slovak.statistics.sk

Enterprises with innovation activity according to SK NACE Rev. 2	Revenue from own performance in mill. €	Expenditure on research and development in thous. €	Number of employees (Average)	Average staff pay in €
2010	1415	4581,91	12179	1986
2011	1749	4873,71	20416	1798
2012	1927	29866,39	21868	1822
2013	2039	20570,67	21600	1853
2014	2205	31193,17	23728	1757
2015	2683	39783,68	25235	1826
2016	2574	42056,39	28338	1727
2017	2660	54556,44	29403	1765
2018	3016	52691,97	33494	1805
2019	3581	68250,72	34929	1972
2020	3641	116492,06	39319	2061
2021	4098	127255,85	41619	2165
Pearson		0,94	0,98	0,58

Table 1 is supplemented with the output of the Pearson correlation coefficient. The above table shows that the value of sales for own performance of the analysed group of enterprises is most strongly influenced by the independent variables average number of employees in the industry (0.98 - according to Cohen, this is a direct almost perfect dependence), expenditure on research and development (0.94). The average salary of employees (0.58) in a given group of enterprises expresses a large influence on the determined dependent variable.

Table 2 provides an overview of the means of the standard deviations and the number of elements of the variables that enter the multiple linear regression.

Table 2 Descriptive Statistics. Source: own processing

	Mean	Std. Deviation	N
Revenue	2632,3333	826,48339	12
Expenses	49347,7467	38890,82092	12
Pay	1878,0833	136,43610	12
Employees	27677,3333	8554,12190	12

The correlation matrix using Pearson's coefficient of linear correlation was performed to check the multicollinearity of the research sample. The input values are processed in Table 3.

Table 5 Correlations. Source: own processing

		Revenue	Expenses	Pay	Employees
Pearson Correlation	Revenue	1,000	,943	,576	,975
	Expenses	,943	1,000	,684	,937
	Pay	,576	,684	1,000	,474
	Employees	,975	,937	,474	1,000
Sig. (1-tailed)	Revenue	.	,000	,025	,000
	Expenses	,000	.	,007	,000
	Pay	,025	,007	.	,060
	Employees	,000	,000	,060	.
N	Revenue	12	12	12	12
	Expenses	12	12	12	12
	Pay	12	12	12	12
	Employees	12	12	12	12

According to the interpretation of the Pearson correlation coefficient provided by Hinkle et al. (2003) and the results obtained by us, we can claim that there is a dependence between our chosen independent variables. Rabušić - Soukup - Mareš (2019) provide a correlation coefficient value of no more than 0.8 as a condition for the relevance of the data. In our case, this condition is not met between the independent variables R&D expenditures and the average number of employees.

However, it is important to check the adequacy of our assumption about the linearity of the relationships by using the R Square and Adjusted R Square data. Table 4 expresses the adequacy of the assumption of a linear relationship between the variables.

Table 6 Model Summary, Source: own processing

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	,984 ^a	,969	,957	171,82434	,969	82,167	3	8	,000

a. Predictors: (Constant), Employees, Pay, Expenses

b. Dependent Variable: Revenue

The reliability of the model (R Square) reaches 96.9%, indicating the amount of variance of the dependent variable explained by our chosen independent variables. The value of Adjusted R Square is 95.7%. This figure is important

since this is a small data set. According to Rabušic - Soukup - Mareš (2019), the above result is favorable for the following analysis.

The output of the multiple linear regression is the application of ANOVA (see Table 5).

Table 7 ANOVA, Source: own processing

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7277633,839	3	2425877,946	82,167	,000 ^b
	Residual	236188,828	8	29523,604		
	Total	7513822,667	11			

a. Dependent Variable: Revenue

b. Predictors: (Constant), Employees, Pay, Expenses

The ANOVA model meets the significance condition ($\text{Sig.} \leq 0.05$). The model is statistically significant. The final output of the multiple linear regression is elaborated in Table 6.

Table 8 Coefficients^a. Source: own processing

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.		
		B	Std. Error	Beta				
1	(Constant)	-1993,939	1506,576		-1,323	,222		
	Expenses	-,002	,006	-,116	-,405	,696		
	Pay	1,108	,688	,183	1,610	,146		
	Employees	,096	,023	,997	4,207	,003		
Model		95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
		Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-5468,109	1480,232					
	Expenses	-,016	,012	,943	-,142	-,025	,048	20,833
	Pay	-,479	2,695	,576	,495	,101	,304	3,285
	Employees	,044	,149	,975	,830	,264	,070	14,298

a. Dependent Variable: Revenue

The linear function of the research analysis has the form:

$$y = -1993,939 + (-0,002 * Expenses) + (1,108 * Pay) + (0,096 * Employees)$$

Expenses (Expenditure on research and development) has a negative effect on the dependent variable Revenue from own performance. An increase of one unit in expenditure on research and development decreases the amount of revenue from own performance by 0.2%. The positively influencing variables are the variables Average number of employees and Average staff pay.

We also examined the homoscedasticity and heterodestaxity condition, which is shown in Figure 2.

The VIF value is not within the recommended interval, due to the multicollinearity confirmed above.

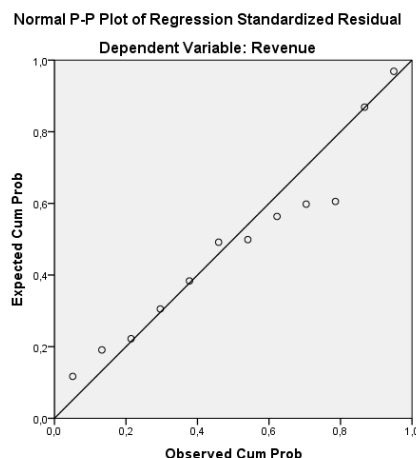


Figure 4 Plot of the normal distribution of residues. Source: own processing

The data do not show an ideal straight line, but they are not very far from a straight line. They come from the normal distribution of the data. We consider the model to be statistically significant.

We have also turned our attention to the analysis of the intensity of innovation of the group of enterprises analyzed. However, the Statistical Office of the Slovak Republic aggregated this information over a two-year time interval. The input information for the calculation of the intensity of innovation is presented in Table 7.

Table 9 Input data for innovation intensity SK NACE Rev. 2. Source: own processing by slovak.statistics.sk

Year	Spending on innovation in thous. €	Revenue on innovation business in thous. €
2008	6083	539879
2010	11352	781994
2012	36438	692887
2014	32950	928717
2016	62621	1402074
2018	82039	1538182
2020	128517	2021586

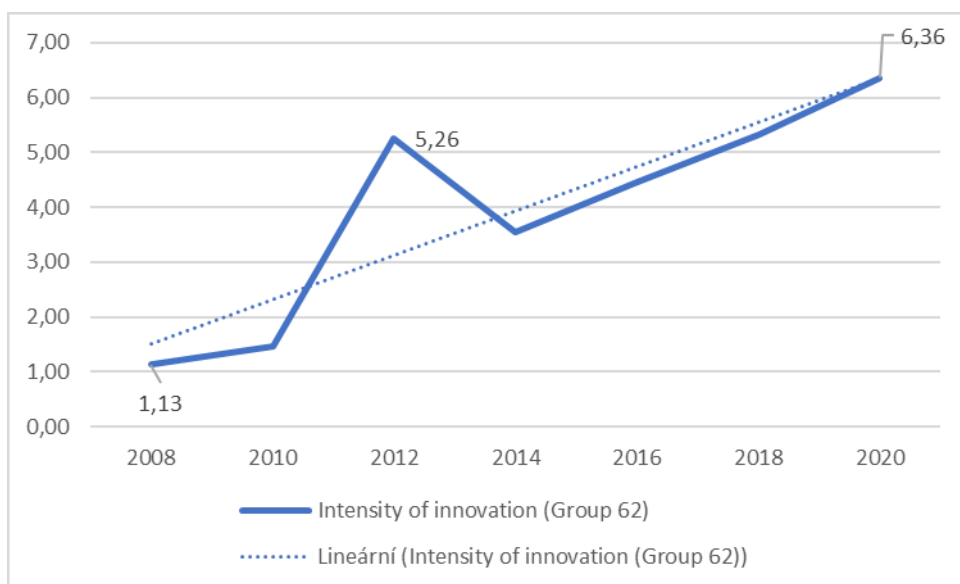


Figure 5 Intensity of innovation SK NACE Rev. 2 group 62. Source: own processing

The intensity of innovation in the field is increasing. The linear function of the innovation intensity of the group of enterprises 62 versus time has the form: $y = 0.8094x + 0.6971$. The reliability of the linear link of innovation intensity trends versus time is 76.23%.

5 Conclusion

Information technology is an integral part of every modern enterprise. In this paper, we use an analysed sample of enterprises from 2008 to 2021 to highlight the importance of IT innovation, which takes various forms. To maintain a company's position in the market, the management of a business must identify the essential factors that are integral to its success. Effective management requires the elimination of errors in production processes. Multiple linear regression confirmed that employees and their motivation play an important role in innovation activities. The influence of financial motivation was also investigated for which purpose we observed the average wages in the business sector. We found that research and development expenditures, which are directly related to innovation, are another important factor. Thus, among the essential factories influencing the value of an enterprise we can consider, the motivation of employees (financial evaluation), their number as well as the expenditures made on R&D in innovative enterprises.

The intensity of innovation in the IT industry has an increasing tendency over time. We recommend that enterprises pay more attention to R&D spending and the financial motivation of employees.

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Analysis of innovation performance of small and medium-sized enterprises in the Slovak Republic

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Abstract. International competition drives innovation and boosts economic growth. The way countries adapt and increase their innovation potential is crucial for their long-term economic performance and competitiveness. The paper focuses on the analysis of innovation performance of enterprises within the Slovak Republic. The basic indicator that is used to support corporate innovation in a country is research and development expenditures. The paper focuses on the approach of corporate R&D funding through different sectors, whether private or governmental, which are compared internationally with EU countries. Subsequently, enterprises are examined in terms of size and the basic division into small, medium and large enterprises in the Slovak environment. As innovation is an important tool for enterprise development, we predict the development of innovative enterprises up to 2025 based on available data from the previous period. The paper concludes by pointing out the current main barriers to the development of innovative activities in enterprises.

Keywords: Innovation, innovation performance, R&D, innovation barriers, cluster analysis.

JEL Classification: C38, O30, O31

1 Introduction

Innovation performance is most commonly used as a performance indicator in innovation research. Hauschidlt et. al. (2016) defines innovation performance as the extent to which the return on invested capital corresponds to the firm's original target or level of return. The authors also emphasize the financial dimension of innovation performance. Proper measurement of innovation and the use of innovation data from research can help policy

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makers better understand economic and social change, assess the contribution of innovation to social and economic goals, and monitor and evaluate the effectiveness and efficiency of their policies (Oslo Manual, 2018).

At the national level, GDP is considered as a typical indicator that seeks to illustrate the innovation-related performance of an economy. However, the advantages of using GDP are certainly the historical databases available and the fact that the indicator is an internationally accepted indicator of performance (Gotsch, 2012). In order to assess country positions and the effectiveness of government interventions related to innovation policies at the national level, policy makers need to have some measurements of the innovation level and performance of different countries. The most common way of comparing the performance of different innovation systems is through the use of indices and rankings due to their operational relevance for decision-making (Sonrexa - Moodie, 2013). The Global Innovation Index (GII) and the Summary Innovation Index (SII) are the most well-known ways of measuring and evaluating a country's innovation performance (Albulescu - Draghici, 2016). This index is based on 32 indicators related to research and innovation.

For businesses, innovation indicators are essential to manage and control the number of innovative ideas and concepts that are presented to them. Defining selection criteria is essential for the efficient allocation of resources and for assessing performance at each stage of the innovation process (Dewangan - Godse, 2014). Innovation activities in Europe are mostly driven by R&D investments made by public organisations and by firms' non-R&D spending on innovation. To a lesser extent, innovation activities are driven by venture capital and R&D activities carried out by the private sector (Ringberg et. al., 2019). Fostering an innovation orientation has more positive effects on firm performance than generating the results of the innovation process, such as patents or innovative products or services. Allocating increased resources to innovation input processes positively affects the innovation-performance relationship (Rosenbusch et. al., 2011). Several EU funding programmes have been established to support innovation activities in organisations, such as the Horizon 2020 innovation strategy (Montmartin - Herrera, 2015), which is now being seamlessly followed by the new Horizon Europe strategy until 2027 (European Commission, 2022).

2 Data and methodology

To evaluate innovation performance at national level, data were collected through the Eurostat database and the European Innovation Scoreboard (EIS), which uses the latest Eurostat statistics and other internationally recognised sources available at the time of analysis to ensure comparability across countries.

Using cluster analysis, we attempt to identify relatively homogeneous groups of cases based on selected characteristics using an algorithm that starts with each case in a separate cluster and merges the clusters until only one remains. In our case, we chose to cluster EU countries based on R&D expenditure by different sectors. The Ward's method was used in this analysis, which aims to combine the cases so as to minimize the variance within the cluster. For this purpose, each case starts as its own cluster. Subsequently, the clusters are merged to reduce within-cluster variability. More precisely, two clusters are merged if this merging leads to a minimum increase in the sum of squared errors. That is, at each stage, the average similarity of the cluster is measured. The difference between the cases within a cluster and this average similarity is calculated and squared. The sum of the squared deviations is used as the within-cluster error measure. A case is selected for a cluster if it is the case whose inclusion in the cluster causes the smallest increase in error as measured by the sum of squared deviations (IBM, 2022).

Since the innovation performance of countries is also affected by other factories that are included in the EIS database, we decided to analyze these factories through correlation. In our analysis, we used the normalized score of the Slovak Republic, which was calculated using the EIS data over an eight-year period. The following were chosen as basic indicators of innovativeness:

- Innovators: SMEs with product innovations (% share), SMEs with business process innovations (% share),
- Linkages: Innovative SMEs collaborating with others (% share), Public-private co-publications per million population, Job-to-job mobility of Human Resources in Science & Technology (% share),
- Intellectual assets: PCT patent applications per billion GDP (in PPS), Trademark applications per billion GDP (in PPS), Design applications per billion GDP (in PPS),

- Finance and support: R&D expenditures public sector (% of GDP), Venture capital expenditures (% of GDP), Direct government funding and government tax support for business R&D,
- Firm investments o R&D expenditures business sector (% of GDP), Non-R&D innovation expenditures (% of turnover), Innovation expenditure per person employed,
- Use of information technologies: Enterprises providing training to develop or upgrade ICT skills of their personnel (% share), Employed ICT specialists (% of total employment).

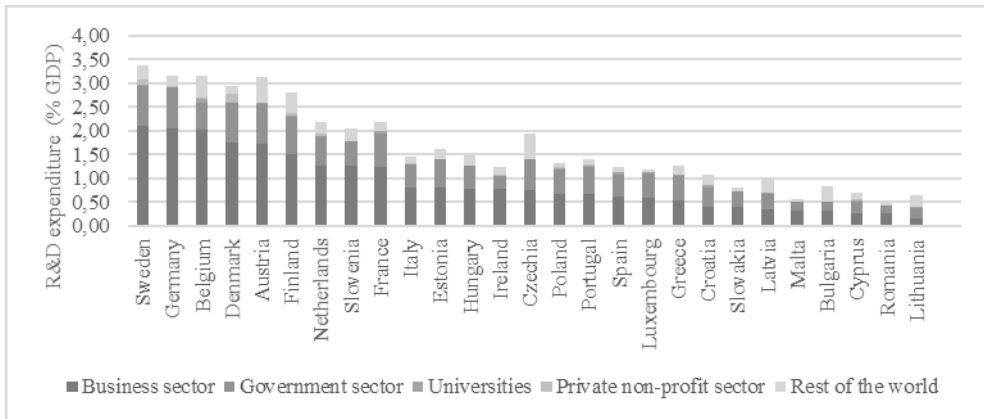
In assessing innovation performance at the enterprise level, data were obtained through the Statistical Office of the Slovak Republic between 2001-2020. Enterprises were divided on the basis of size categories into small, medium and large enterprises. On the basis of the available data, a prediction model is developed which shows the expected development of enterprises with innovation activity up to 2025. The evolution of the share of all enterprises with innovation activity in the total number of enterprises in industry and selected services is also predicted. The prediction model was created using IBM SPSS software, which uses a forecasting feature while providing advanced features that allow to make reliable forecasts using time series data. The table also includes the upper confidence limits (UCL) and lower confidence limits (LCL) for the forecasted values (95% by default).

3 Results

Since the financing of innovation is quite difficult to quantify at the macroeconomic level, we therefore use R&D expenditure to illustrate the financing of innovation. We compare the structure of corporate R&D funding across EU countries.

We can observe in the graph 1 that corporate research and development is mainly financed by private business entities and, to a varying extent, from sources coming from abroad. The private business sector supports R&D mainly in countries such as Belgium, Denmark, Finland, France, Germany, the Netherlands, Portugal and Sweden at a level of between 1.26-2.11 % of GDP. In contrast, it is least supported in countries such as Bulgaria, Cyprus, Lithuania, Slovakia and Romania at between 0.15-0.39% of GDP. Government funding also plays an important role. Countries such as Germany, Denmark and Austria are the most supported by this form of

government at between 0.84-0.88% of GDP. The least supported countries are Bulgaria, Malta and Romania, where support amounts to 0.2% of GDP. Resources from abroad support R&D mainly in countries such as Austria, the Czech Republic, Belgium, Finland but also Bulgaria, at between 0.32-0.53% of GDP.

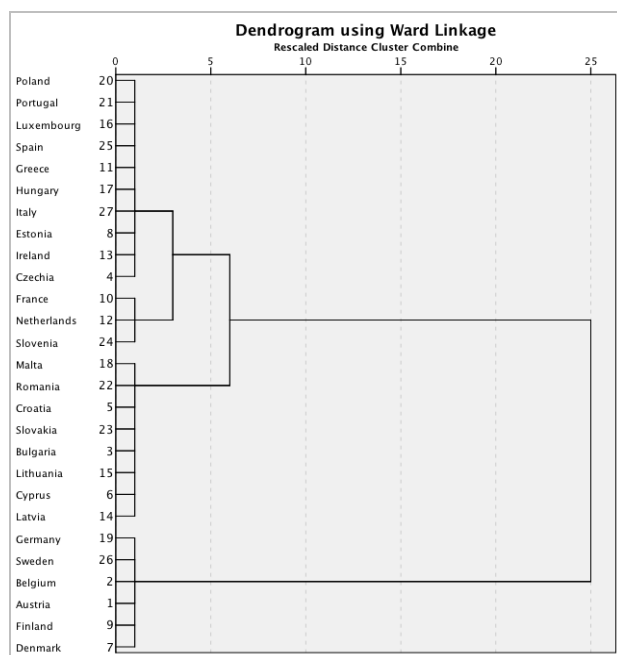


Graph 1 Structure of R&D funding in EU countries in 2019, Source: Own processing based on Eurostat data

As well as examining the Summary Innovation Index, which classifies countries into four categories of innovation leaders, strong innovators, moderate innovators and weak innovators, we decided to create a hierarchical cluster analysis and classify countries according to their funding of R&D activities into four categories. The following chart shows the distribution of countries into clusters according to the structure of corporate R&D funding in 2019.

In graph 2 we see that the first cluster formed is between the countries Poland-Czech Republic, these countries were jointly classified as moderate innovators in 2019, except for Luxembourg, Estonia and Ireland, which were among the strong innovators. The second cluster formed based on corporate R&D funding, with France as a strong innovator, the Netherlands as an innovation leader and Slovenia as a moderate innovator. The third cluster formed is the extremes between Malta and Lithuania. Slovakia has also been included in this cluster, acting as a moderate innovator. Countries such as Romania and Bulgaria are regularly ranked as weak innovators and their innovation performance lags well behind the EU average. In the last cluster formed, we include mostly innovation leaders such as Sweden, Denmark and

Finland; the remaining countries in the cluster rank among the strong innovators but tend to move towards the leaders in the future on the basis of substantial corporate R&D funding.



Graph 2 Dendrogram of the structure of R&D funding in EU countries in 2019, Source: own processing

Table 1 shows the correlation of the factors that affect countries' innovation performance. In order to be able to compare each indicator between countries with different variables, we use the normalized scores from the EIS database, which were calculated based on an eight-year average. The core indicators are innovators factor, firm linkages, intellectual assets, business financing and support, business investment, and information technology use.

According to the data in Table 1, statistically most important is the relationship between the indicator innovators and linkages ($r = 0.767^{**}$), thus indicating that linkages between innovating firms have a positive impact on overall innovation performance. Since the innovators indicator directly examines SMEs with product and business process innovations, we see that the second most significant relationship is with firm investments ($r = 0.658^{**}$), so that R&D expenditures in the business sector, have an equally positive impact on the innovation performance of firms.

Table 1 Correlation between innovation indicators, Source: own processing

	Innovators	Linkages	Intellectual assets	Finance and support	Firm investments	IT
Innovators	1					
Linkages	,767**	1				
Intellectual assets	,438*	,572**	1			
Finance and support	,483*	,690**	,551**	1		
Firm investments	,658**	,618**	,578**	,704**	1	
Use of IT	,436*	,710**	,703**	,595**	,586**	1

Legend:

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

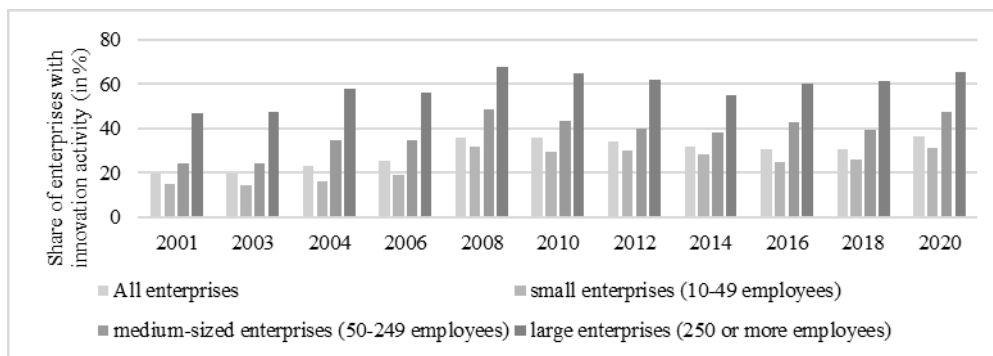
Information technology has the lowest impact on indicator innovators ($r = 0.436^*$). In our research, there is also a significant association between indicator linkages and information technology ($r = 0.710^{**}$), firm investment and finance and support ($r = 0.704^{**}$) and use of information technology and intellectual assets ($r = 0.703^{**}$).

3.1 Innovation performance at enterprise level

In the framework of the study of innovation performance at the enterprise level, we observe the share of enterprises with innovation activity in the total number of enterprises in industry and selected services in the Slovak Republic. We also track these enterprises by small, medium and large enterprises.

Figure 3 shows the evolution of the number of innovating enterprises between 2001 and 2020 from the database of the Statistical Office of the Slovak Republic. The number of all innovative enterprises increased most significantly between 2001 and 2008. The almost twofold increase in the number of innovative enterprises in this period was mainly supported by the fact that the Slovak Republic had the opportunity to draw on EU funds for the first time in 2004-2006 and to encourage an innovative approach in enterprises. The subsequent programming period 2007-2013 was the first programme period for the Slovak Republic to benefit from EU funds throughout its entire duration, bringing the number of innovating enterprises

to between 36.1-31.8%. The highest rate of all innovative enterprises was in the last reporting period, at 36.6%, as the Horizon 2020 strategy, which is now being smoothly followed by the new Horizon Europe strategy until 2027, started to run out of funds.



Graph 3 Share of enterprises with innovation activity in the total number of enterprises,

Based on the observed data for each individual size category of enterprises, a prediction model was created, which shows the expected possible development of innovation activity of enterprises up to 2025.

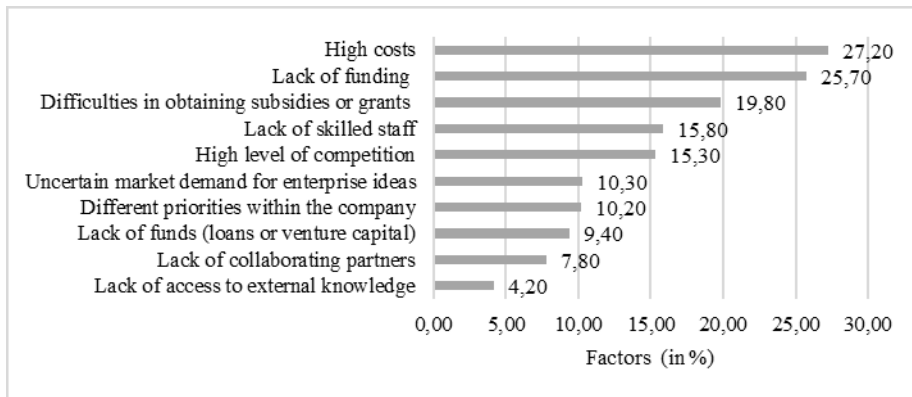
Table 2 Forecasting the evolution of the number of innovating enterprises, Source: own

Model		2022	2023	2024	2025
All enterprises	Forecast	37,46	38,31	39,16	40,02
	UCL	43,70	47,15	49,99	52,52
	LCL	31,21	31,21	28,34	27,52
Small enterprises (10-49 employees)	Forecast	32,00	32,81	33,61	34,42
	UCL	38,84	42,47	45,45	48,08
	LCL	25,17	23,15	21,78	20,76
Medium – sized enterprises (50-249 employees)	Forecast	48,76	49,92	51,08	52,24
	UCL	58,85	64,19	68,56	72,42
	LCL	38,67	35,65	33,60	32,06
Large enterprises (250 or more)	Forecast	65,60	65,60	65,60	65,60
	UCL	74,57	78,28	81,13	83,54

employees)	LCL	56,63	52,92	50,07	47,66
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In Table 2 we see that the number of all enterprises that bring innovation to the country's economy should increase steadily. The potential for growth in innovation activities is currently supported mainly by the European Union's operational programmes, but also by cooperation between enterprises, which has already proved to be a significant indicator in the correlation between the factors. The biggest innovators in the country are predominantly large enterprises, with more than half of enterprises in industry and selected services marketing innovative solutions. The upper confidence limit for large enterprises shows up to a 10% increase in the number of innovative enterprises by 2025. The government in the country should encourage and develop opportunities to promote innovation in small and medium enterprises, which contribute significantly to higher employment growth, output, export promotion and entrepreneurship promotion in the country.

The emergence of innovation is a complex process, and businesses face many obstacles in the innovation process. Based on the Community Innovation Survey 2020, which was processed by the Statistical Office of the Slovak Republic, the main barriers to the development of innovation in enterprises in the Slovak Republic have been identified and are shown in Figure 4.



Graph 4 The main limiting factors for innovation activities. Source: own processing based on the CIS

The main factor limiting innovation activities is considered by 27.2% of innovating enterprises to be too high costs of launching new or improved products or services. 25.7% of enterprises do not have enough internal funds within the enterprise, which could be used for further innovative ideas.

Difficulties in obtaining government subsidies or grants were reported by 19.8% of innovating enterprises. Another barrier is the lack of experts and qualified employees, which means that enterprises have to spend additional funds on training employees, and also too much competition on the market. As the Slovak Republic provides a relatively small market for potential customers, 10.3% of innovating enterprises perceive this as a significantly limiting factor. Other significant constraints include the lack of financing through loans and venture capital and also the insufficient number of cooperating enterprises, resulting in an underdeveloped market for innovation clusters and R&D centres.

4 Conclusion

Innovation plays a vital role in economic growth, improving living standards and the development of society. Innovation activities should create the conditions under which enterprises can stimulate and improve their innovation performance. In the introduction of this paper, we analysed the structure and impact of R&D expenditure on innovation performance, which was compared across EU countries. Corporate R&D in the Slovak Republic has been financed predominantly by private business entities and, to varying degrees, by sources from abroad. We then explored the link between R&D expenditure funding and overall innovation performance through cluster analysis. Countries were divided into 4 categories, following a similar distribution methodology in the Summary innovation index. The assessment using this index provides an overview of the strengths and weaknesses of their research and national innovation systems, helping individual countries to identify areas for improvement. In this analysis, the Slovak Republic ranked at the bottom of the overall ranking in terms of innovation performance and R&D funding, putting it in the same league as countries such as Bulgaria and Romania. These countries are among the weak innovators, where we can also include the Slovak Republic.

Next, we examined the correlation between factors that largely influence innovation performance. The most significant correlation was between the innovator indicator, which represents SMEs with product or business process innovation, and the linkage indicator, which represents the linkages between innovative firms. Other significant indicators of innovativeness were financial support to enterprises and the correlation between the use of

information technology and linkages with innovative SMEs was also significant.

SMEs contribute significantly to the economic activity and innovation performance of countries. To analyse innovation performance at the enterprise level, we examined the evolution of the number of enterprises with innovation activity out of the total number of enterprises in industry and selected services, based on which we predicted the evolution of the number of innovative enterprises by 2025. In the Slovak Republic it is necessary to focus in particular on strengthening cooperation between enterprises, creating linkages, clusters and building common infrastructure of enterprises, applied research and development, as well as export support. Most enterprises rely on internal funding and have limited possibilities for external financing of innovation activities. Increasingly, entrepreneurs are using external capital or various financial grants and subsidies. European Structural Funds and Community programmes provide an important source of funding for research, development and innovation. In addition, there is a need to improve the quality of research centres, to support training and to pay more attention to promoting the commercialisation of innovative solutions.

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DIITALIZATION OF PUBLIC ADMINISTRATION

The development of intelligent organizations in the context of digital transformation

Piotr Adamczewski¹

Abstract. The impact that the digital transformation (DT) has on businesses, suppliers and other third parties has increased significantly now. Digital transformation means improving traditional manufacturing processes with the help of digital technologies. The goal of digital transformation is to increase production efficiency and reduce costs, improve the quality of goods and services produced, and quickly adapt to changes in the global market. The state of industrial production is constantly changing due to the instability of global, economic and political decisions, so the adoption and expansion of digital solutions based on Industry 4.0, the Internet of things, machine learning and other technologies of the future is accelerating. With the help of these technologies, companies are trying to change approaches and find new ways to solve problems. In this article was analyzed the phenomenon of a complex system of knowledge management with tools as SMAC, AI, IoT and Edge computing in intelligent organizations as a part of intelligent economy. The arguments are illustrated with the results of own research conducted by the author in 2021-2022 in selected SMEs from the Polish Wielkopolska Province and their reference to the general development trends in this area.

Keywords: intelligent organizations, digital transformation

JEL Classification: C53

1 Introduction

Progress in digital technology has led to new business opportunity and changed the way in which organizations create, deliver, and capture value. Traditional companies could fail in operationalizing their digital transformation approach because they believe that they can pursue digitalization simply by applying new IT technologies. Digitally enabled organizations are supported by emerging digital technologies, which increasingly promise great opportunities for growth. These digital technologies embrace ICT systems such as mobility, analytical systems, and virtualization and are integrated with back-office ICT in order to provide a holistic view of the digital organization. Such initiatives are known as being

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part of the Digital Transformation (DT) of organizations and require them and their respective management to react on the process of implementation. With the shift to digitalization, organizations cannot focus their behaviour and reaction only on the physical/traditional world. Managers in any organization must be able to recognize and anticipate technology-enabled change, assess its potential and impact, and understand how to leverage digital technology in order to capture and create value for their organizations. Successful management of an organization in a digital era requires rethinking the organizational strategy, business model, and key business drivers [13].

Competition is accelerating faster than ever before; the rise of digital and fintech start-ups is changing global competitive dynamics; mobile is becoming the channel of choice; the innovation pipeline and consumer expectations are changing. The technology and competitive landscape are evolving dramatically, and traditional industries and incumbents are challenged to embrace digital transformation. Digital transformation is not an easy process. There are no standard road maps for digital transformation and companies need to overcome various obstacles to successfully develop digital transformation. The lack of technological and financial resources to invest in new high-tech solutions as well as of digital skills among internal employees, the low awareness of the potential of adopting digital solutions and the reluctance of management to activate new working and management methods are the most common factors that hinder digital transformation. Often, hiring digital experts and investing in digital technology seems to be the optimal solution to address the challenges of digital transformation. However, this creates only a technological store window, with digital experts remaining isolated and other employees unaware of the reasons for technological transformation. The critical challenge is that digital transformation is not just technology and it requires a radical shift in cultural and corporate attitudes. The real challenge is developing and facilitating the gradual implementation of a company's digital strategy and sharing a digital plan that aligns the company's strategic vision and employees ambitions [10].

The increasing rapid diffusion of digital technologies makes digitalisation a strategic imperative for most organisations. Responding to digitalisation, organisations need to digitally transform themselves by developing and integrating digital technologies across all business units, from structures and products to processes and business models. Therefore, digital transformation

can be understood as a holistic transformation process of organisations and entire industries driven by technological developments entailing far-reaching strategic, organisational, and socio-cultural changes. Digital transformation in organisations leads to significant changes that organisations need to manage. On the one hand, organisations can reduce transaction costs and increase revenue by introducing digital technologies. They can generate novel value creation and capture mechanisms by introducing new business models and gaining competitive advantages. On the other hand, introducing digital technologies is a time-consuming, often threatening, uncertain, and potentially costly process.

Nevertheless, digital transformation is essential not only for large organisations but also for small- and medium-sized enterprises (SMEs) with their immense importance to the economy [16]. However, they also face specific characteristics (e.g., lack of technological assets) and peculiarities (e.g., resource constraints) that hinder digital transformation. Today, organisations face the challenge of transforming their whole organisational structures and processes in all business units due to the increasing use of novel digital technologies. The resulting changes have fundamentally altered customer expectation and behaviour (e.g., the anticipation of novel ways to interact and engage with customers), putting immense pressure on established firms and disrupting numerous markets. However, digital technologies offer a broad spectrum of new opportunities; many firms are struggling to explore and exploit the potential of new digital technologies and innovations. Given the importance of digital transformation in maintaining organisational competitive advantage, several excellent reviews have taken stock of the rapidly growing literature. Nevertheless, it is striking that many studies focus on individual areas of application fields of digital transformation. Yet, the literature misses a consensus on a generally accepted definition.

2 Intelligent organizations in the digital transformation

The most important characteristics of a intelligent organization include, among other [7], [12]:

- fast and flexible operation,

- the ability to monitor the environment,
- the capacity to diagnose early market signals and to react to changes in the environment, and
- the ability to implement new knowledge-based solutions and achieve economic benefits therefrom.

The growing volume of information used in a intelligent organization is accompanied by its increasing importance. Peter Drucker indicated already that traditional factors of production, such as growth, labour, and capital, are losing their importance in favour of a key resource, namely knowledge applied in the creative operation of an organization. It constitutes intangible resources that are related to human actions, whose use may be the basis for gaining a competitive advantage [17]. Knowledge has to be treated as information embedded in the context of an organization and a skill to use it effectively in the organizational activity. It means that knowledge resources are data about its customers, products, processes, environment, etc. in a formalised form (documents, databases) and in non-codified forms (knowledge of staff).

In the practical dimension, the effective collaboration of such elements means the necessity to use advanced ICT solutions. Technical, technological, and organizational innovations, which have appeared in recent years, are all utilised [2]. They encompass almost all areas of a modern organization operation, starting from means of transport and equipment, through organization and material and raw material flow management, to the development of system structures that implement business processes, i.e. within logistics systems that are the essence of modern management based on ICT solutions.

The present effect of the ICT evolution in the form of the so-called third ICT platform, has been treated since 2013 as the foundation of the 4th industrial revolution, being the natural development stage of the 3rd revolution of 1969 (its symbol being electronics with its transistor and automated production). The main distinguishing element of new changes has become the redefinition of the present course of business processes that contributes to new operating models of economic organizations facing new challenges to maintain their position and expand on the market further. The industrial revolution of the 4th stage is breaking out due to [6], [8], [9]:

- the introduction of the all-present digitalization,
- decision processes based on virtual simulations and data processing in real time, and
- machine-machine and machine-man communication.

The digital transformation means a change of the present approach to a customer and a comprehensive process where an organization moves to new methods of operation using the state-of-the-art SMAC digital technology, including social media, mobility, big-data – analytics, and cloud computing. However, it has to be kept in mind that the role of digital technologies in that process is to enable the necessary changes and open an organization to new opportunities. Therefore, they should be a tool rather than the aim of transformation. The centre of the process has to be the customer and his needs, as the main driver for manufacturers and service providers. The digital transformation is no longer the method of gaining a competitive advantage – it is becoming a factor that enables to stay on the market [5], [11].

3 Trends in the digital transformation

Digital transformation is being spearheaded through a combination of software and hardware advancements. While the list of advancements is endless, the most promising technologies fall under one of the four umbrella terms described below briefly [1], [3], [5], [14].

I. The Data Science Trio refers to three advancements related to data science that are arguably causing the greatest disruptions across various industries at present. These three technologies are:

- Data Analytics and Big Data Analytics refers to a set of qualitative and quantitative methodologies used to study and extract knowledge from raw data and use it to guide business decisions. Big Data refers to gargantuan data sets that contain important information and patterns hidden among large heaps of supplemental data. Both finite data analytics and big data analytics are applicable in virtually any scenario involving a database and sufficiently large amounts of data. Scores of companies are currently hiring armies of Data Analysts to crunch through their datasets and help them improve/organize their practices and services.

- Machine Learning refers to the concept of giving computers the ability to learn on their own without human intervention. The primary usage of machine learning is to teach computers to recognize patterns on their own in cases where human analysis is too slow, expensive, or even impossible. Machine learning has thus seen itself being employed in recommendation engines, market analyses, spam filters, network security solutions, and more. Any organization that has data-based assignments which are large & repetitive (or) involve some form of identification tasks (or) a combination of both the above, should consider exploring machine learning solutions.
 - Artificial Intelligence (AI) refers to a computer possessing the ability to perform a task or tasks in a manner that is just as effective or even more effective than a human being doing the same. While machine learning deals with a computer studying data and merely outputting what it has learned, Artificial Intelligence deals with a computer studying data and taking decisions/executing tasks based on certain pre-programmed instructions. A.I is best implemented in any scenario requiring high speed and high precision decision making and task execution.
- II. Internet of Things (IoT) refers to a network of interconnected physical devices and sensors that collect data and exchange it with one another using the internet as a communication platform. IoT networks allow for low cost embedded systems to be deployed into physical environments where they can continuously collect information, relay it, interpret it, and act on it accordingly. IoT helps in achieving a scenario where all variables of a physical environment can be mapped and each constituent device's functioning can be made to depend on said variables or outputs from other device(s). For this reason, IoT has found immense value in health-care, smart cities, and smart homes.
- III. Remote Work Environments. High skilled employees are very often not available at the desired location of a firm or may sometimes prefer to work from home. In the digital age, it makes no sense to compromise on talent by restricting hiring & work to a single physical location. Whether it is employees situated halfway across the world in a satellite office, or an employee situated half way across town in their own house, technological

advancements such as video calls and internet-connected project management software allow us to send work to employees themselves when the reverse is not possible.

- IV. Block Chain Technology. The finance industry is currently undergoing one of its largest transformations in history – thanks to blockchain. Blockchain refers to a distributed global database spanning across millions of computers all over the globe. It is not controlled by any central authority and uses state of the art cryptography to prevent unauthorized access to sensitive information such as transaction history. Blockchains have already been implemented to create cryptocurrencies (e.g. Bitcoin) which are unregulated digital currencies that offer alternatives to traditional currencies. Cryptocurrencies are used widely due to the unmatched security and freedom they offer in trading any amount of money, big or small, without having to face any bureaucratic trouble.
- V. Other Promising Trends. Beyond the technologies discussed above, there are several other technologies promising digital disruption of legacy industries. Some of the most promising trends are [6]:

Trend No. 1: Operationalizing AI Initiatives - for the majority of organizations, continuously delivering and integrating AI solutions within enterprise applications and business workflows is a complex afterthought. Gartner expects that by 2025, 70% of organizations will have operationalized AI architectures due to the rapid maturity of AI orchestration initiatives. Organizations should consider model operationalization (ModelOps) for operationalizing AI solutions. ModelOps reduces the time it takes to move AI models from pilot to production with a principled approach that can help ensure a high degree of success. It also offers a system for governance and lifecycle management of all AI (graphs, linguistic, rule-based systems and others) and decision models.

Trend No. 2: Efficient use of data, models and compute - as organizations continue to innovate in AI, they also need to efficiently use all resources — data, models and compute. For example, composite AI is currently about combining "connectionist" AI approaches like deep learning, with "symbolic" AI approaches like rule-based reasoning, graph analysis, agent-based modeling or optimization techniques. The result of combining those

techniques (among others) is a composite AI system that solves a wider range of business problems in a more efficient manner.

Organizations can apply generative AI that creates original media content, synthetic data and models of physical objects. For example, generative AI was used to create a drug to treat obsessive compulsive disorder (OCD) in less than 12 months. Gartner estimates that by 2025, more than 30% of new drugs and materials will be systematically discovered using generative AI techniques.

Trend No. 3: Responsible AI - the more AI replaces human decisions at scale, the more it amplifies the positive and negative impacts of such decisions. Left unchecked, AI-based approaches can perpetuate bias leading to issues, loss of productivity and revenue.

While algorithms can deduce race and gender from proxy parameters, such as typical female names or postal codes with the dominant racial demographics, more implicit bias is difficult to spot. For example, a data scientist might overlook that a number of clicks on the website can be discriminatory against age. AI can perfectly classify a stereotypical Western wedding but be blind to the weddings in India and Africa.

Moving forward, organizations must develop and operate AI systems with fairness and transparency and take care of safety, privacy and society at large.

Trend No. 4: Data for AI - by 2025, more than 30% of new drugs and materials will be systematically discovered using generative AI techniques. Disruptions such as the COVID-19 pandemic are causing historical data that reflects past conditions to quickly become obsolete, breaking many production AI and ML models. D&A and IT leaders are now turning to new analytics techniques known as “small data” and “wide data.” Taken together, they are capable of using available data more effectively, either by working with low volumes of data or by extracting more value from unstructured, diverse data sources. By 2025, Gartner expects that 70% of organizations will be compelled to shift their focus from big to small and wide data, providing more context for analytics and making AI less data-hungry.

4 The digital transformation pyramid

The concept behind digital transformation is how to use technology to remake a process so that it becomes more efficient or effective. It's not just about changing an existing service into a digital version but improving it. Some of the technologies used in digital transformation projects are IoT, blockchain, big data, cloud computing, AI, and machine learning. Digital transformation is more than just adding technology - part of the transformation includes changing how employees think. If the corporate culture doesn't support change, then it will be difficult for a company to instill new business processes and reach digital enlightenment. The shift to a digitally transformed business often means breaking down silos and relating differently to customers.

Such technologies determine changes in three areas of intelligent organizations that apply them through:

- developing relations with customers and counterparties owing to the deeper understanding of their needs, introducing numerous channels of communication, and enriching forms of self-service,
- improving operational processes within internal organizations and working environment as well as mechanisms of monitoring their efficiency, and
- modelling organizational operations within product manufacturing and services provided on the market.

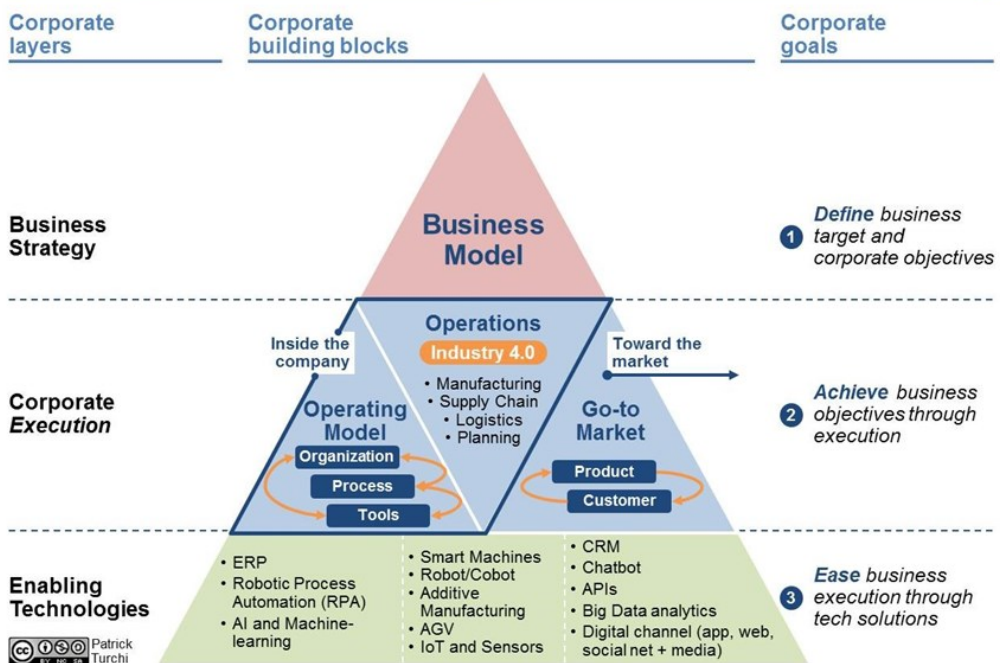
There are three levels on which Digital Transformation needs to be approached within corporates - Figure 1 [18]:

- Business strategy,
- Corporate execution,
- Enabling technology.

An effective digital transformation program has to embrace at least two of the three levels – and, ideally, it must cover (in the long term) each of the three levels. For example, the definition of a new 'Digital' Business Model, without its execution through a new Go-to Market approach, is a pure theoretical exercise that will remain at board-level presentation and will not change the way a business performs. On the other hand, the implementation of a new ICT system (such as an ERP or CRM) or the set-up of a standalone e-

commerce is not a digital transformation initiative, if this is not part of an overall operating model transformation or of a new Go-to Market approach. It is important to acknowledge that each of the three level of the pyramid has a strong influence on (and actually defines) the other elements of the framework. A successful digital transformation program, in fact, requires a "system" approach to embrace a truly transformational initiative. Strategy, execution or technology alone cannot transform a company: only an integrated review of (at least) two of the elements enables corporate transformation.

The Digital Transformation pyramid



- Operations,
- Operating model,
- Go-to market,
- Technology.

Each of the elements is relevant and the relationship among the elements must be taken into consideration in digital transformation initiatives. In fact, a new way of 'doing business' (both inside the company and in relation to the market) is the way a digital transformation program properly works. As a matter of fact, technologies impact the operating model and the operations of

a company, as well as supporting the evolution of the Go-to market (for example through a new channel approach or through the review of the product portfolio or product features). Similarly, business model implementation requires the definition (and evolution) of specific operating models, operations activity and market approach.

Layer 1: Business Strategy (Business Model)

When defining the business strategy in a digital (or digitally-enabled) environment, corporates have to evaluate opportunities and impacts (as well as potential threats) of technology-enabled business models (or digital business models), such as (but not limited to):

- Platform business and marketplace,
- Ownership model evolution (with the shift from ownership to access, through pay-per-use models),
- Value-added services through digital technology,
- Data-based products (and services).

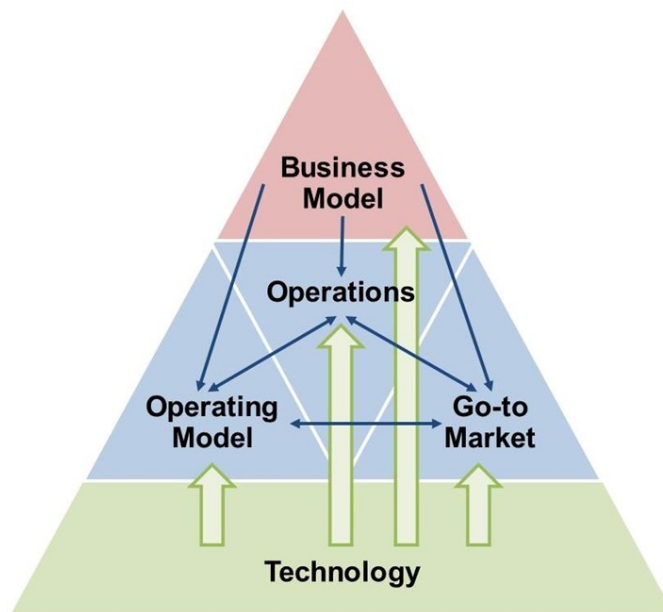


Figure 2. The Digital Transformation Pyramid, Source [18].

Layer 2: Execution

It is not clear whether Sir Winston Churchill actually said “However beautiful the strategy, you should occasionally look at the results”, but the point here is

clear: execution is the key for corporate transformation, and Digital Transformation programs do not work differently. Execution works in fact in two directions: inside the company and outside the company (toward the market, or the markets the company is willing to serve).

There are three building blocks of execution:

- Corporate operating model,
- Operating model of operations,
- Go-to market approach.

Each of the blocks requires a specific deep-dive, since each of the 3 building blocks is actually made of further elements, and every one of them requires special attention when developing a digital transformation initiative. Nonetheless, it is important to keep in mind that, at this level, the strategy defined is realized through the very founding elements of a corporate:

- Product and customer: which defines the offer of the business (taking into consideration key elements, such as selling price, distribution channel, promotion and communication approach, digital-enabled product value proposition, etc.),
- Organization, procedure and tools, which - through the operative model - outline the structure of the corporate and the way it works,
- Operations, constitute the way the corporate realizes products (and services) that is willing to push into the market.

Those elements are, of course, the standard components of the strategy execution and are not only relevant in a digital transformation context. Nonetheless, it is important to highlight that in this context they require a specific approach through the evaluation of the digital and technological impact. For example, what is the "product" in a digitally-enabled context such as car-sharing platforms? Is it the service provided, the arrival at the final destination, the access to the car, the time needed, etc? And consider that the very definition of "product" has then an impact on the definition of the price, the value provided, the core product offer, etc.

Layer 3: Technology

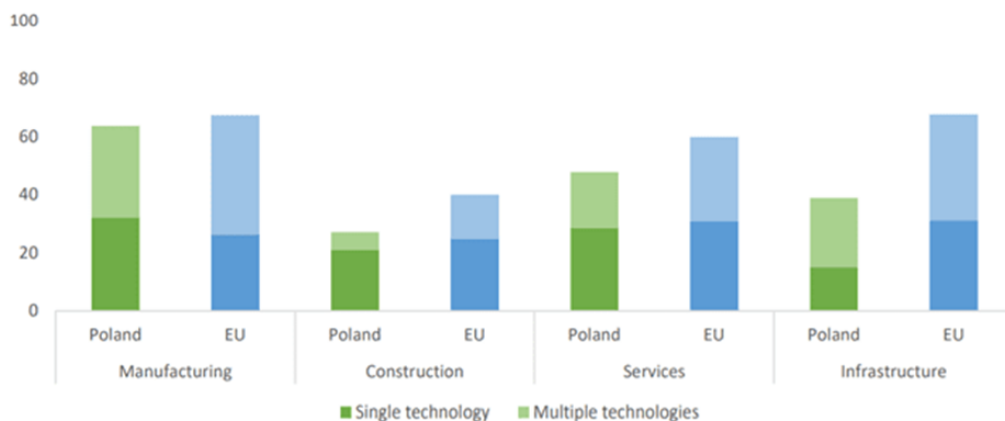
As mentioned at the beginning, technology is not the core of digital transformation, but is actually its enabler. Technology serves (and supports) the realization of the business target and objective through the 'execution' blocks. Technology is the enabler of the evolution of the operating model, of operations (with Industry 4.0 approach) and the realization of the Go-to market approach. On the other hand, technology is the driver of changes on each level of the pyramid, and being able to identify the impact of technology on each level of the pyramid is a key strategic corporate capability. It is important to identify business changes in the market driven by technology and to define strategic responses (or possibly anticipate with the correct strategic move) [15], [19].

5 Case Study of the Polish SMEs

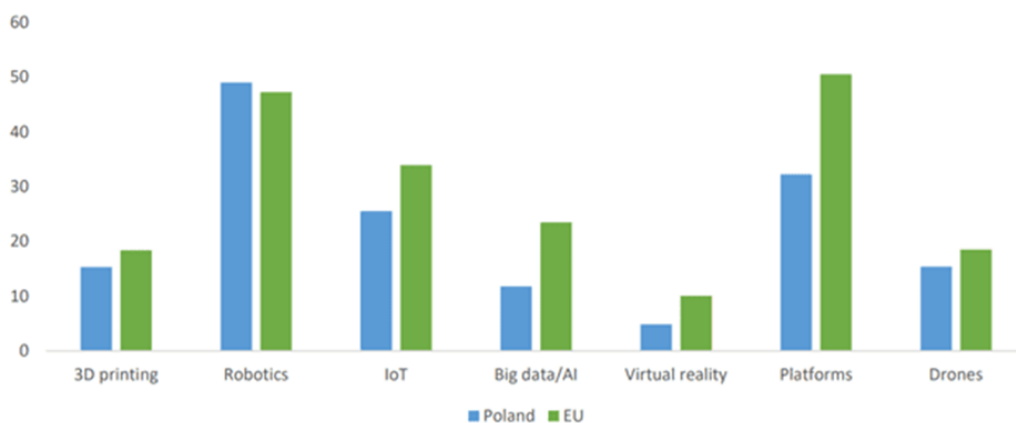
The European Investment Bank's (EIB) report "Digitalisation in Europe 2020-2021" places Poland below the EU average in terms of digitalisation in four areas: manufacturing, construction, services and infrastructure – especially in infrastructure, our country implements significantly fewer digital tools compared to the other EU members [4]. The analysis of specific technology branches included in the aforementioned EIB report shows that the only area in which Poland is nearing the EU average is robotics – Figure 3 and Figure 4. Other branches, i.e., 3D printing, Internet of Things, BigData, AI, virtual reality, platforms and drones remain below the EU level. The main strength of Poland is industry – many companies from this sector have begun to take measures to embrace digital transformation.

The analysed DESI indicator shows that Poland needs to accelerate its efforts so that enterprises may start availing of the possibilities of digital technologies. In the long term, the measures taken should have positive effects through better connectivity, the higher digital skills of society and workers, and the greater involvement of businesses in the digital economy. Unfortunately, Poland is still lagging behind in this field, although there has been a stable increase in this area as compared to the EU average. In the coming years, this area requires further development and must be integrated with other dimensions, e.g. with the availability of high-speed Internet connections, affordable devices and services of professionals from the ICT sector, and also be supported by development activities stimulated at the national level by public administration

Adoption of digital technologies (% of firms), by sector



Adoption of different digital technologies (% of firms)



enterprises operate on the basis of action plans not exceeding one year. This type of planning was particularly common in micro-enterprises employing up to 10 people and running a service activity. This was partly due to the specific conditions in which economic entities had to operate and the need for quick adjustments to the changing situation. Digitization acted as an important process in the activities of the analysed enterprises. Every fifth surveyed enterprise had plans to invest in software and digital solutions for enterprises; and wanted to implement these plans within the next year. In the group of enterprises employing from 51 to 250 people, over 75% entities have either already made such investments or plan to carry them out over the course of the coming year. As shown by the analysis of the surveyed enterprises, the most common area of activity and implementation of digital solutions was sales and distribution. This was due to the need during the pandemic to build new distribution channels for products or services through

the increasingly important e-commerce market. The benefits were very practical, and in the main closely related to economic conditions. Among the benefits of using digitization, the most frequently mentioned were the desire to increase the enterprise's revenues and a willingness to adapt to the market situation. These types of conditions were directly related to the epidemiological situation in 2020 and the drive to transfer significant areas of activity to the Internet.

Research has shown that the Covid-19 situation has led to significant changes taking place in the economy of enterprises. In every fourth of the analysed enterprises, revenues dropped by more than 20%. An up to 20% decrease in revenues occurred in 28.3% of enterprises. This must have had a negative impact on investments also in the area of digitization. More than half of the analysed enterprises indicated a lack of financial resources as a barrier when introducing cloud solutions. This confirms the hypothesis presented in the introduction.

The COVID-19 outbreak has resulted in a sharp and significant decline in transport, production and consumption. At the same time, thanks to the development of digitization, it has become possible to work and learn remotely. It turned out in practice that information and communication technologies (ICT) play an important role in the life of modern people. These technologies become an inseparable part and accompany him in every area of life. They also affect the replacement of energy-consuming working methods and lifestyles with more ecological ones, in line with the idea of sustainable development. It is to be hoped that the research and analysis of issues related to the functioning of digitization in enterprises from the SME sector will allow at least a part to fill the existing gap in the literature. Aspects related to the use of digitization introduced in the era of the Covid 19 epidemic should be permanently included in the strategies of operations of enterprises from the SME sector. Increasing the support for new digital and innovative business models, and the further encouraging of digitization, would help enterprises to enhance efficiency, as well as enabling SMEs to become both more efficient and more competitive.

Research carried out by the author shows that the popularity of ICT support in management processes in Polish SMEs can be presented as follows (percentage of analysed enterprises)² :

- finance and accounting – 98%,
- human resources – 92%,
- warehouse management – 89%,
- production management – 68%,
- customer relationship management – 87%,
- office work support – 99% (including e-mail 98%), and
- procurement and sale process service – 88%.

The readiness of the studied entities to face the challenges of digital transformation is as follows:

- 29% of respondents answered positively, confirming the implementation of such tasks,
- 18% of respondents answered that such actions would be taken soon,
- 21% of responses indicated that such actions would be taken in the near future, and
- according to 32% of respondents such actions were not being conducted and there were no such plans.

As regards the use of SMAC, AI, IoT and Edge computing solutions, the statistics of the analysed entities reflect the general global trend in this respect, i.e. (Riche, 2018; Schwab, 2016):

- a cloud is used in 58% organizations (38% of analysed population plans to start using it),
- mobility is utilised in 49% of organizations (with 15% of analysed population planning to launch it),
- analytics is applied by 29% of organizations (while 16% of studied population have plans to start it), and

² The analyses are illustrated with survey results and direct observations of the author from 2021-2022 in selected 120 SMEs from Wielkopolska province in Poland. The survey sample was made up of micro (9%), small (56%) and medium sized enterprises (35%). Surveyed companies represent a wide range of industries: retail and wholesale trade, discrete and process manufacturing, transport, HoReCa, utilities, finance, construction, telecommunication and ICT.

- social media are declared by as many as 55% of organizations already, and their use in the near future is declared by 55% of respondents.

The fact of placing a customer in the centre was confirmed by responses about catching up with the dynamically evolving needs of contemporary consumers. Moreover, half of the respondents indicated the necessity to follow the changing expectations of their customers, declaring it to be their top business priority. The continuous improvement of customer satisfaction level is possible mostly owing to investments in new ICT solutions. Only owing to them shopping can be comfortable, fast, and possible at any time and place, while customer service can be effective. It also means the new opportunities in acquiring knowledge about needs, behaviour, and opinions of customers. In general, the above-mentioned study results show that Polish modern business organizations are becoming more confident in using advanced solutions of SMAC systems, to meet the challenges of digital transformation [14], [16].

6 Conclusions

The dynamic economic changes and the evolution of business relationships devalue traditional sources of competitive advantages in the SME sector, such as capital, infrastructure, access to outlets, and the quality of offered products and services. Modern enterprises that want to compete on the market effectively have to give priority to flexibility of their organization and its ability to implement innovative business models and reorganise logistics processes. Examples of numerous Polish SMEs show that the vision of a business managed in a modern way has come into the dynamic phase of realization, while the effective knowledge management with advanced ICT solutions is growing to the role of paradigm. There is no doubt that reserves still present in the SME sector can be utilised, through supporting its operation with advanced ICT systems with the dominant role of SMAC solutions.

Nevertheless, it has to be remembered that the creation and development of such smart technologies has one basic aim for businesses, namely to accelerate the development pace and improve the quality of offered products and services, while reducing operating costs. Although it seems apparently simple, paradoxically innovation of Polish business organizations from the

SME sector is burdened with the concern about the unknown. SMEs are afraid of investing in solutions that are not popular yet. Nevertheless, the strategic vision of the management in such organizations will determine the directions and pace of popularising modern and effective solutions in knowledge management, which may contribute to the improvement of their competitiveness on the global market.

SMAC, AI, IoT and Edge computing solutions opens up a new frontier for digital business. This is because virtually every application, service and IoT object incorporates an intelligent aspect to automate or augment application processes or human activities. Digital representations of things and organizational processes are increasingly used to monitor, analyze and control real-world environments. These digital twins combined with SMAC and immersive experiences set the stage for open, connected and coordinated smart spaces. Formal mechanisms to identify technology trends and prioritize those with the biggest potential impact on the business create competitive advantage.

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Measurability of E-government

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Abstract. The digital revolution brings with it changes. Changes in the economy, in the character of society, changes in the functioning of organizations and states. The effect of information and communication technologies creates space for easier and faster communication, distances are blurred, in the private and public sector we are looking for signs of decreasing bureaucracy and more transparent access to information.

In 2020, when the global crisis caused by the coronavirus hit the world, we see an opportunity for an even more rapid impact of digitization. The quarantine caused by the pandemic prevents people from meeting, the full-time form of study is interrupted for compulsory school pupils and students, employees lose their jobs or have to take compulsory holidays and businesses close their operations. Thanks to the Internet, this crisis was easier to bear. Relatives who are far from each other stay in touch through social networks. Students switched to a distance form of education in the form of electronic lectures and lessons. If it is necessary to visit any institution, electronic communication and therefore e-Government is preferred.

The concept of e-Government is relatively young. It is generally referred to as the electronification of public administration.

Keywords: e-Government, EDGI, DESI, TOPSIS, digitalization.

JEL Classification: H83, C39, O38

1 Introduction

Digitization generally refers to the process by which information is transformed into a digital format using digital technologies to improve activities and processes within an organization. The term "digitization" is the name for the process of transferring available information and existing resources to digital media that can be read by a computer. It is about changes and transformation in the world because of information and communication technologies. (IGI Global, 2022)

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Digitization is one of the highest priorities of the European Union. The European Parliament is participating in the formation of new legislation that would strengthen European capacities in the field of digital technologies and would bring new opportunities for both individual citizens and companies. Digitization should also be helpful in the transition to a more ecological economy and in achieving climate neutrality. The European Union aims to improve citizens' digital skills, provide training for workers, and move to digitization in public services. (Európsky parlament, 2022)

2 E-Government

The IGI Global dictionary (2022) states that under the term e-Government we can understand the implementation of information and communication technologies in public administration. Through organizational changes, new procedures, and skills, it is trying to achieve increased efficiency in the provision of services and increased transparency. In essence, these are public administration services that are accessible online through information and communication technologies (E-GOVERNMENT Sylaby, 2020)

It is about digital interaction on several levels between public administration and citizens, public administration with the business sector, but also between public administration institutions and each other. (itapa.sk, 2022)

In connection with an individual citizen, it is possible to mention electronic services such as requirements related to housing (property tax, temporary residence), vehicle registration, driver's license, travel documents, health insurance, customs duties, and various taxes (income tax, dog tax, accommodation tax), and include services related to environment and health. In the case of business entities, it is possible to mention various taxes and fees, customs duties, public procurement, various issues regarding business support, termination of business, etc. (Slovensko.sk, 2022)

The concept of e-Government cannot be associated only with the field of public administration, because according to the eGov Act, it is the exercise of public power electronically, which consists of three components. This means that it includes the legislative, executive, and judicial components of public power (electronic judiciary) also, internal processes and relationships within public authorities. (Slovensko.sk, 2022)

3 Indicators of e-Government

The history of e-Government in the territory of the Slovak Republic dates to 1995. In this year, the Act on Public Administration Information Systems was adopted. E-Government is based on the principle of using ICT within the public administration institution. Thanks to these principles, it is possible to effectively fulfill the priorities of the citizens of the Slovak Republic, which are related to the activity and provision of specific services of individual public administration bodies. (itapa, 2022)

We know 2 indicators to monitor the progress and level of development of digitization. At the level of the UN countries, it is the composite EDGI indicator, and at the level of the European Union, we are talking about the DESI index, which is compiled annually by the European Commission. (itapa, 2022)

E-Government Development Index (EGDI)

E-government services are indispensable tools for improving the governance of countries. The higher the level of development of electronic public administration services, the more effective the relations between public administration, citizens, and businesses.

The United Nations (2012) states that "the e-Government Development Index (EGDI) composite indicator is used to measure the willingness and capacity of national administrations to use information and communication technologies to deliver public services."

EGDI is a composite indicator that consists of three indexes (online services index, telecommunications infrastructure index and human capital index) with equal weight. The three indexes that make up the EGDI cover a wide range of topics that are relevant to e-government (The United Nations, 2012):

- Online Services Index - measures the government's ability and willingness to provide services and communicate electronically with its citizens.
- Telecommunication infrastructure index - measures the existing infrastructure through which citizens participate in electronic public administration.

- Human capital index - used to measure citizens' ability to use electronic public administration services.

Like the index itself, its components are classified into 4 levels. The very high EDGI group includes Member States whose index is in the range of 1.00-0.75. The second group consists of countries (high level of EDGI), which acquired values from 0.50 to 0.75 (inclusive). The middle level EDGI group corresponds to the interval 0.25-0.50. And the last group consists of index values lower than 0.25. (The United Nations, 2012)

Online Services Index (OSI)

This index measures 4 levels of internet availability in national authorities. The higher the level, the greater the impact on the index (The United Nations, 2012):

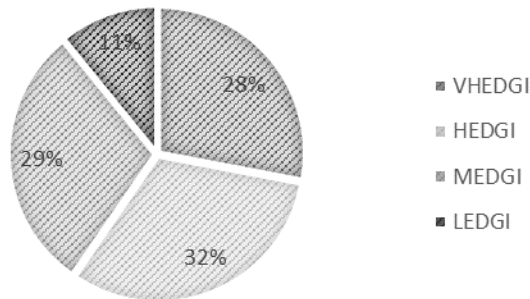
First level - *developing information service*. It measures whether the government's website provides information to citizens in a way that is understandable to the user and whether it provides links to ministries and other government departments.

Second level - *improved information service*. It tests whether the government's website enables one-way or simple two-way communication between authorities and citizens.

The third level - *transaction services*. It measures the extent to which two-way communication between the administration and the citizen is enabled; including the ability to manipulate a wide range of data

Fourth level - *related (additional) services*. It measures the government's activity in web 2.0 applications and the government's ability to provide a wide range of electronic services tailored to different segments of citizens

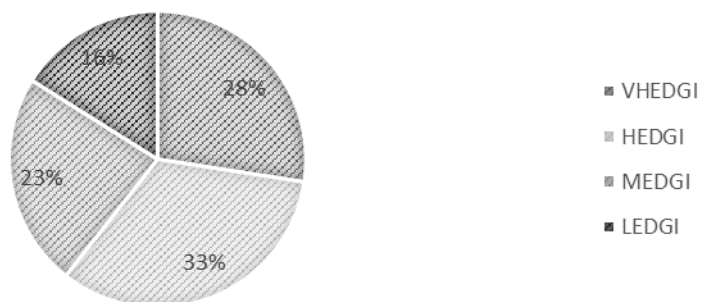
From the data for the year 2022, we find that 28% of the UN member states that were subject to this index have results higher than 0.75. 21 out of 193 UN member states (11%) have negative results and therefore unreliable and non-functional government websites. The highest level of this index was obtained by the Republic of Korea (1.0000) and Estonia (0.9941). Last in the ranking of the OSI index are the countries of Eritrea and South Sudan.



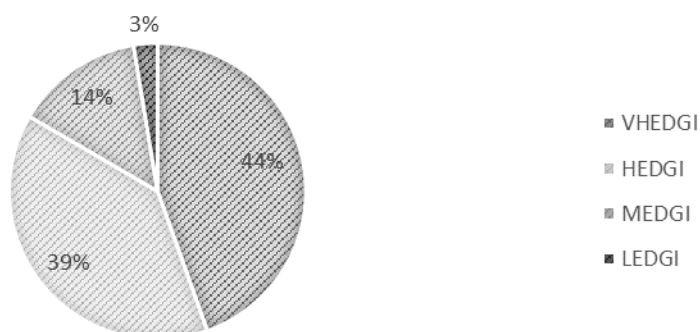
Graph 1 Share of member states - OSI index. Source: United Nations, 2022

Telecommunication Infrastructure Index (TII)

This index consists of the estimated number of Internet users, fixed telephone lines, mobile subscribers, fixed Internet connections and the number of fixed broadband devices for every 100 inhabitants. While the Online Services Index describes the digital presence and capability of governments, the Telecommunications Infrastructure Index measures the ability of a nation's telecommunications infrastructure to enable citizens to participate in all forms of e-government. (U ae., 2022).

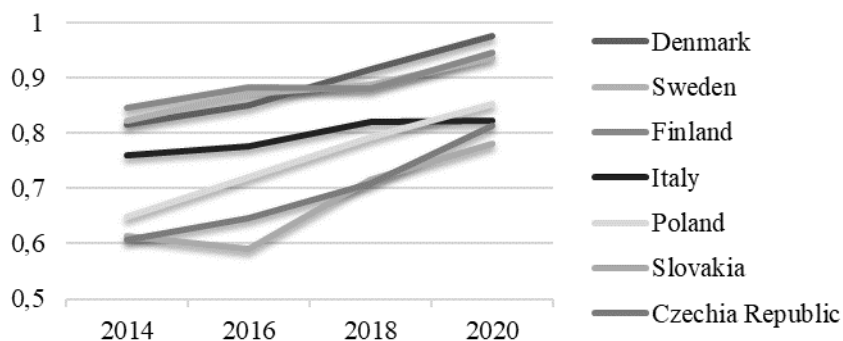


Eritrea and North Korea have the worst access to telecommunications within the UN countries. The 2020 Telecommunication Infrastructure Index stands at 0.000 (Eritrea) and 0.0127 (North Korea), while Liechtenstein is the country with the largest number of people using telecommunications facilities per 100 inhabitants (1,000).



THE EGDI is the result of the indices described above and shows that the worst of all UN countries is South Sudan. If we narrow the circle to European countries, San Marino (0.6175) takes the last place. Slovakia ranks 48th out of all UN countries with an EDGI value of 0.7817. Denmark recorded a significant development. In 2014, it was ranked 16th, in 2016, 9th, and in the last two measurements, it has moved up to first place, marking it as the country with the best value of the E-Government Development Index (EGDI).

Table 10 Development of EGDI of selected UN countries. Source: United Nations, 2022



4 Material and method

Based on the TOPSIS method, we will evaluate which year-on-year development of the second composite indicator of e-Government - the DESI index - is the strongest for Slovakia.

The DESI index uses a combination of 33 indicators in the main areas of measurement. In previous years, the European Commission measured the level of digitization development in five areas. However, the European Commission made changes that concern individual indicators and at the same

time reduced the number of areas for monitored indicators. The area devoted to the use of Internet services was dropped. (mirri.gov.sk, 2022) The areas that were monitored in the DESI index are:

- human capital,
- connectivity,
- integration of digital technologies,
- digital public services.

DESI now includes an indicator that measures the level of support provided by ICT technologies to businesses in adopting environmental measures. This index makes it possible to evaluate the overall level of digitization in the state, it identifies problematic areas that should receive greater attention from the state. (mirri.gov.sk, 2022)

In DESI 2021, Slovakia was ranked 22nd out of 27 member states of the European Union. Based on these results, the European Commission states that Slovakia is making progress, but progress is not fast enough compared to other EU member states.

The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method assesses variants in terms of their distance from the ideal and base variant. This method requires a cardinal evaluation of variants according to individual criteria and the weight of these criteria. The procedure for using this method is as follows (Šubtr et al., 2011):

1. Step: Constructing the normalized criterion matrix $R = (r_{ij})$ according to the relation

$$r_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^p y_{ij}^2}} \quad (1)$$

2. Step: Calculation of the normalized weighted criterion matrix $W = (w_{ij})$ according to the relation

$$w_{ij} = v_j r_{ij} \quad (2)$$

3. Step: Determination of the ideal variant H with the evaluation (h_1, \dots, h_m) and the basal variant D with the evaluation (d_1, \dots, d_m) with respect to the values of the matrix W.

4. Step: Calculation of the distance of individual variants from the ideal variant:

$$d_i^+ = \sqrt{\sum_{j=1}^k (w_{ij} - h_j)^2} \quad (3)$$

and from the basal variant:

$$d_i^- = \sqrt{\sum_{j=1}^k (w_{ij} - d_j)^2} \quad (4)$$

5. Step: Calculation of the relative distance indicator from the basal variant, the so-called benefit indicator, when the maximum value determines the variant with the highest benefit:

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (5)$$

6. Step: Descending arrangement of variants according to utility values c_i

5 Results

To start the analysis, we need to collect all the necessary data such as the DESI index, Human capital, connectivity, Integration of digital technologies and Digital public services. The subject of the analysis is to find out, based on the components of the DESI index (TOPSIS analysis criteria), which of the monitored years has the highest year-on-year increase. The monitored period is the years 2017-2021, year-on-year increases are reconstructed by the alternatives of the TOPSIS method. The following table shows the development of Slovakia's DESI index as well as its components.

The following table shows the development of Slovakia's DESI index as well as its components.

Table 11 The development of DESI index and its components. Source: own processing according to The United Nations, 2022

DESI	HUMAN CAPITAL	CONNECTIVITY	INTEGRATION OF DIGITAL	DIGITAL PUBLIC
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						TECHNOLOGIES		SERVICES	
		Index	change	Index	change	Index	change	Index	change
2017	29,8	37,6		26,01		19,22		36,3	
2018	31,7	38,9	1,3	26,58	0,57	21,97	2,75	39,2	2,9
2019	33,3	40	1,1	27,75	1,17	22,99	1,02	42,3	3,1
2020	36,2	42	2,0	32,01	4,26	24,33	1,34	46,5	4,2
2021	39,9	43,3	1,3	40,63	8,62	26,26	1,93	49,6	3,1
Σ			5,7		14,62		7,04		13,3

Based on formula (1), we will compile the normalized criterion matrix R.

The subsequent step, which is multiplying the criterion matrix by weights, constructs a normalized weighted criterion matrix W. Based on the methodology of the DESI index, each index has a weight of 0.25.

In the next step, we determine the ideal variant H and the basal variant D for individual years. We calculate the distances of individual variants from the ideal variant according to formula (3) and the basal variant (4). In the penultimate step, we determine the benefit indicator for each variant. Finally, we compile the descending arrangement of variants according to the values of utility c_i .

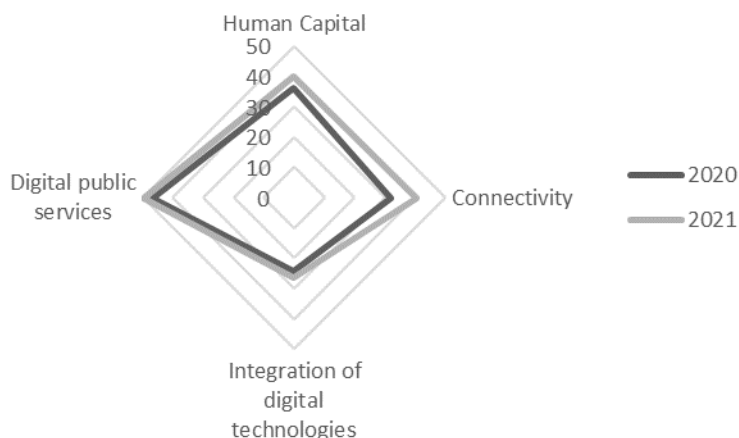
Table 3 Basal variant, ideal variant, and utility. Source: own processing

YEARS	HUMAN CAPITAL	CONNE CT.	INTEGRATI ON OF DIGITAL TECHNOLO GIES	DIGITA L PUBLIC SERVIC ES	d_i^+	d_i^-	c_i
2017/2018	0,1109	0,0147	0,1829	0,1078	0,116	0,221	0,345
2018/2019	0,0938	0,0301	0,0679	0,1152	0,017	0,240	0,067
2019/2020	0,1706	0,1098	0,0891	0,1561	0,133	0,146	0,476
2020/2021	0,1109	0,2221	0,1284	0,1152	0,217	0,091	0,705
IDEAL VARIANT H_j	0,1706	0,2221	0,1829	0,1561			
BASAL VARIANT D_j	0,0938	0,0147	0,0679	0,1078			

From the above table and calculations of the TOPSIS method, it follows that the most significant development of the DESI index is recorded between 2020 and 2021. This is the period that was most affected by the corona crisis.

6 Conclusion

In the submitted contribution, we have brought together two indices that can be used to determine the development of e-Government in Slovakia. One of them is the EGDI index, which is compiled every 2 years by the United Nations, and the other is the DESI index from the workshop of the European Commission. In both cases, it is obvious that the digitization of public administration in Slovakia is improving with each subsequent measurement, but we still point out that Slovakia is in the middle of the tables. In the article, we wanted to find out which year-on-year increase in the DESI index is the strongest for Slovakia using the TOPSIS method. Through analysis, we found that it was the corona period (2020/2021) that helped to strengthen this index as well as its components. Based on the graph 2 we see that the Connectivity index recorded the highest year-on-year increase. This index includes the increase in the percentage of households covered by fixed networks with very high capacity provided in connection infrastructures using an optical cable to the building, or campus (FTTP) and DOCSIS 3.1, namely 67% compared to 50% in 2020. (DESI, 2022)



Graph 2 Components of DESI index 2020/2021. Source: own processing according to European Commission

In terms of human capital, Slovakia ranks 19th among the 27 EU countries, and is thus below the EU average. 55% of Slovaks have basic digital skills, which is slightly above the EU average of 54%. However, only 21% of Slovaks have advanced digital skills, which is below the EU average of 26%. The share of companies that provide their employees with ICT training is at the level of 16%, compared to the EU average of 20%. (DESI, 2022)

Slovakia is below the EU average for all monitored indicators of the Digital Public Services index. The share of e-government users among Internet users has decreased to 62% and is below the EU average of 65%. Regarding the category "amount of pre-filled data in public online forms", the country scored 45 points in 2020, which is below the EU average of 64 points. Digital public services for citizens are also below the EU average, scoring 65 points compared to 75 points at EU level. (DESI, 2022)

Within the EU, Slovakia was ranked 21st in the field of digital technology integration by businesses. 43% of Slovak SMEs have at least a basic level of digital intensity, which is below the EU average of 55%. The share of enterprises that use big data analysis is at the level of 6%, compared to the EU average at the level of 14%. The country's e-commerce score has worsened: 13% of SMEs sell online, compared to 17% the previous year. The share of SME turnover from e-commerce also fell to 8% (EU average: 12%). (DESI, 2022)

Based on the analysis carried out, which assessed that the strongest increase in the Government of Slovakia is between 2020 and 2021, and facts from the annual report Digital Economy and Society Index (DESI) 2022, compiled by the European Commission, we concluded that despite the annual growth of the index the level of digitization in Slovakia is not sufficient, sometimes below the EU average.

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Information technology in waste management

Josef Bělíca¹, Václav Zyder², Jakub Chlopečký³

Abstract. Waste management is a relatively new technological sector that directly affects all stages of the production and consumption cycle of the cycle - from the extraction of mineral resources, through the production, transport and consumption of products and services, to their disposal, when after the expiry of their lifetime, they become waste. Waste management as a system is a set of measures and partial activities both in IT and in human activities, where the structure of waste and its origin, including various ways of handling it, is very interesting. The so-called Waste Catalog is used, which is a basic registration obligation, mainly with handling and waste disposal obligations.

Keywords: Waste management, municipality, information system, waste.

JEL Classification: O3

1 Introduction

In general, the entire issue of waste and its management is currently being mentioned more, in connection with the adoption of the new Act on Waste, i.e. Act No. 541/2020 Coll. Waste Act. It is obvious that world globalization does not only have a positive trend and impact on the world, but also brings with it an increase in global waste production. There is no doubt that waste has a very negative effect on the environment, polluting it for many years to come, and in connection with waste there is a fact of impact on human health, soil, air and surface and subsurface water pollution). Future development trends in the field of waste are predicted at a negative pace, i.e. an increasing waste load on the environment is predicted. Not only these reasons lead to changes in directives and laws of the European Union, but also of the Czech Republic, see the amendment to the Waste Act. When the goal should be to reduce waste production through modern technologies and with the help of the waste hierarchy, first take care of the creation of waste, followed by reuse or use in the energy sector. All legal regulations respond to

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reducing the volume of waste production and thus the effort to reduce negative impacts on the environment through the so-called principles of the circular economy.

1.1 Waste management

Waste management is based on the hierarchy of waste management, according to which the priority is to prevent the generation of waste, and if it is not possible to prevent the generation of waste, then in the following order its preparation for reuse, recycling, other use, including energy use, and if it is not possible that, its removal. [1,6,7]

In the Czech Republic, the first law on waste was established in 1991. Currently, waste management is governed by Act No. 541/2020 Coll., Waste, which is effective from 1 January 2021. The Act sets out the rights and obligations of persons in the field of waste management and promotes the basic principles of the circular economy, environmental protection and human health when dealing with waste. The management of end-of-life products is regulated by Act No. 542/2020 Coll., effective from 1 January 2021. The management of packaging waste is regulated by Act No. 477/2001 Coll., on packaging, as amended. [6,7]

Act No. 541/2020 Coll. The Act on waste within waste management states as follows:

- 1) Waste management means an activity focused on preventing the generation of waste, on waste management, on the subsequent care of the place where waste is permanently stored, mediation of waste management and control of these activities.
- 2) Waste management is based on a hierarchy of waste management, according to which the priority is to prevent the generation of waste, and if the generation of waste cannot be prevented, then in the following order its preparation for reuse, recycling, other use, including energy use, and if it is not possible even that, its removal.
- 3) The interpretation and application of this law must be in accordance with the hierarchy of waste management.
- 4) When applying the hierarchy of waste management, it is taken into account

- a) the entire life cycle of products and materials, especially with regard to reducing the effects of waste management on the environment and human health,
 - b) the precautionary and sustainability principle,
 - c) technical feasibility and economic sustainability,
 - d) protection of resources, the environment, people's health and economic and social impacts a
 - e) goals, principles and measures of the Waste Management Plan of the Czech Republic.
- 5) It is possible to deviate from the hierarchy of waste management in the case of waste for which, taking into account the overall impacts of the life cycle of products and materials including the generation of waste and its management, it is appropriate with regard to the best result in terms of environmental protection and human health.

2 Information system of waste management

The Waste Management Information System (ISOH) is a comprehensive and nationwide database information system containing data reported on the basis of Act No. 185/2001 Coll., on waste and on the amendment of certain other acts, Act No. 541/2020 Coll., on waste and Act No. 477/2001 Coll., on packaging and amending certain laws, as amended. Through gradual development, the information system reached its current form, where almost all reported data is processed on the basis of the above-mentioned laws and their implementing legislation. [5,11,12]

The following are accessible to the public:

- The Public Information System of Waste Management (VISOH), which makes available aggregated data on waste production and management in the basic territorial division of the Czech Republic in two modules (module 1 from 2002 to 2008 and module 2 from 2009 to the present), serves especially the professional public with an orientation in the applicable legal regulations in the field of waste management, [1,2,10,11,12]
- The list of manufacturers of electrical equipment, which in its public part provides information on how to fulfill the obligations of manufacturers of electrical equipment, authorized representatives and

collective systems within the framework of the take-back of electrical equipment, [10,11,12]

- Register of electrical equipment take-back points, which provides information on collection containers and collection points (collection points, collection yards, stores, etc.) where non-functioning electrical appliances can be returned, [2,3,4,5,11,12]
- Car wrecks module (MA ISOH), which includes the Public overview of MA ISOH facilities, which contains a list of facilities for the collection and processing of car wrecks with a valid operating permit, [2,3,4,5]
- Register of facilities, traders and files, which provides up-to-date information on waste management facilities operated in accordance with Act No. 185/2001 Coll. and from 1 January 2021 also Act No. 541/2020 Coll.,
- List of carriers, which contains information on waste carriers who are not at the same time a person authorized to take over waste in their possession according to § 13, paragraph 2 of Act No. 541/2020 Coll. [6,7]

Environmental legislation obliges economic entities to report to public administration institutions information on the impact of their economic activity on the environment. These entities thus become whistleblowers from the field of the environment, while the obligation to submit a report is imposed in the relevant legal standards. The reporting party's duty is to deliver relevant reports to state or public institutions that are required by the relevant legal standard to check reports, or to assess fees. The reports contain information about air, water and soil pollution, waste registration or, for example, the disposal of electrical equipment or the registration of car wrecks in the respective facilities.

ISPOP is established in accordance with § 4, paragraph 1 of Act No. 25/2008 Coll., on the integrated register of environmental pollution and the integrated system for fulfilling reporting obligations in the field of the environment and on the amendment of certain laws, as amended.

The founder of ISPOP and the administrator of ISPOP according to Act No. 365/2000 Coll., is the Ministry of the Environment.

According to Act No. 365/2000 Coll., ISPOP is operated by the Czech Environmental Information Agency. [6,7]

2.1 ISPOP system and selected indicators in model municipalities

Model situations of the use of the ISPOP information system in municipalities were defined for three sizes of the municipality. The first municipality is the statutory city of Havířov, the second is the company OZO Ostrava, a.s., which provides waste management for the model municipality of Pustějov, and the third model municipality is the municipality of Rychvald. [6,7]

[illegible]

Figure 1 Screenshot of the ISPOP report for the city of Havířov

The picture shows the basic characteristics of such an overview, which is filled in manually in the ISPOP system. The next picture defines the reporting of individual waste items in an abbreviated form.

Figure No. 2 already shows the types of waste that were entered into the ISPOP report, such as tires, oil filters, brake fluids, etc. In the report, you can statistically monitor the total amount of waste, the waste classification code and the partner who is responsible in the municipality for waste management. The second reporting deals with figure No. 3, which is defined for the company OZO Ostrava, a.s., which processes waste for the municipality of Pustějov.

[illegible]

Figure 2 Screenshot of the ISPOP report for the city of Havířov

[illegible]

in the ISPOP information system

Figure No. 3 shows the first part of the annual report on waste and secondary raw materials of the municipality of Pustějov.

Figure No. 4 shows the individual types of waste, the total amount, the waste code and the amount of waste that was handled in kg.

The last model municipality is the municipality of Rychvald, where the first part of the reporting is shown in Figure No. 5.

Ministerstvo životního prostředí

(3) Název hlášení (v) Doplňné hlášení
Evidenční číslo hlášení: Hlášení 1746616

V případě doplňného hlášení je nutno zaslat optimálně celý formulář včetně všech přílohových dat.
Hlášení o produkci a nakládání s odpady

Vycházející rok: 2021

Hlášení uvozuje pro PRP (název): B102 Buchumín

Lístek č. 1 - Identifikace původce nebo oprávněné osoby
Celkový počet stran hlášení: 7

Původce nebo oprávněná osoba - údaje platné od 31.12.2021	Název provozovny: Název hlášení (3) AND (v) NE
Právní forma:	
ICO: 202978155	(v) Adresa samostatně provozující je shodná s adresou sídla (z Adresy samostatně provozující není uveden a)
Označení firmami-uváděna a přijímá: Město Rychnov	Adresa sídla
Místo: Olomučka (p.p. 678 E.p.)	Sídlo provozu (3) AND (v) NE
Okres: Rychnov	(v) IEP O SEZ O SOOP samostatně dle provozování ICOP/S
PSC: 73032	Název provozovny: Město Rychnov
Kód ORP (SOPT): B102	Město: Olomučka (p.p. 678 E.p.)
KČLJL: 999107	Obec: Rychnov
Datum vyhodnocení hlášení: 11.5.2022	PSC: 73032
Poznámka k hlášení:	Kód ORP (SOPT): B102
	KČLJL: 999107
	Hlášení vyplní:
	Jméno: TOMAS Připravil: ZONASEK
	E-mail: zponasek@rychnov.cz
	Tel.: +420731414258
	Pro zařazení bylo vydáno integrované povolení O AND (v) NE
	Provozovna je součástí zapojena do obecného systému sběru a nakládání s komunálními odpady: NE
	Obec obsahuje údaje o obecném systému nakládání s komunálními odpady: Ano

Slide No. 6 already shows the name of the type of waste, its catalog number, the amount of waste, the company that is responsible for managing waste in the given municipality and, for example, the category of waste.

Ministerstvo životního prostředí Příloha č. 20 k vyhlášce č. 383/2001 Sb.

LIST č. 2 - Hlášení o produkci a nakládání s odpady za vykazovaný rok

IOČ/ID 00297615 Identifikační číslo zařízení, skladu u původce, obchodníka nebo provozovny (IOČ/IOČ/ID) 5 Číslo strany listu č. 2 2

ICZU provozovny 599107 Počet stran listu č. 2 7

Přijímatel ID	Kategorie odpadu (dle přílohy č. 1)	Název druhu odpadu	Množství odpadu (tun)		Kód zpracování	Partner IOČ, obchodní firma/obchodní a příjmový, ICZ/ICP, adresa, ICZU provozovny	Číslo ověření
			Celkem (t)	Z toho de stabilizace 7.1.3			
1	2	3	4	5	6	7	8
1	150110	N	Ostatní odpadový materiál	0,22	ANO		
	150110	N	Ostatní odpadový materiál	0,1	ANO	(Firma) 4880712, FCC Česká republika, s.r.o., CZN0205, Dabice 17184, Rychvald, 599107	
	150110	N	Ostatní odpadový materiál	0,03	ANO	(Firma) 4880712, FCC Česká republika, s.r.o., CZN0187, ST 17814, Rychvald, 599107	
	150110	N	Ostatní odpadový materiál	0,09	ANO	(Firma) 2562054, Služby města Rychvald, spol. s r.o., CZN0187, ST 17814, Rychvald, 599107	
2	150202	N	Asfaltový šedák, šedák materiálu	0,12	ANO		
	150202	N	Asfaltový šedák, šedák materiálu	0,12	ANO	(Firma) 4880712, FCC Česká republika, s.r.o., CZN0205, Dabice 17184, Rychvald, 599107	
3	180103	O	Pneumatiky	17,725	ANO		
	180103	O	Pneumatiky	5,2	ANO	(Firma) 4880712, FCC Česká republika, s.r.o., CZN0205, Dabice 17184, Rychvald, 599107	
	180103	O	Pneumatiky	2,33	ANO	(Firma) 4880712, FCC Česká republika, s.r.o., CZN0187, ST 17814, Rychvald, 599107	
	180103	O	Pneumatiky	10,195	ANO	(Firma) 2562054, Služby města Rychvald, spol. s r.o., CZN0187, ST 17814, Rychvald, 599107	
4	170101	O	Beton	136,5	ANO		
	170101	O	Beton	136,5	ANO	(Firma) 2562054, Služby města Rychvald, spol. s r.o., CZN0187, ST 17814, Rychvald, 599107	
5	170102	O	Čistý	30,5	ANO		
	170102	O	Čistý	30,5	ANO	(Firma) 2562054, Služby města Rychvald, spol. s r.o., CZN0187, ST 17814, Rychvald, 599107	
6	170203	O	Plasty	0,73	ANO		
	170203	O	Plasty	0,73	ANO	(Firma) 4880712, FCC Česká republika, s.r.o., CZN0187, ST 17814, Rychvald, 599107	
7	170604	O	Isolantní materiály, recyklovací podíl (tun)	15,73	ANO		
	170604	O	Isolantní materiály, recyklovací podíl (tun)	15,73	ANO	(Firma) 2562054, Služby města Rychvald, spol. s r.o., CZN0187, ST 17814, Rychvald, 599107	

Seznamy hodnot podle přílohy č. 20 k vyhlášce č. 383/2001 Sb.

Figure 6 Report on waste production in the city of Rychvald through the ISPOP information system

2.2 Discussion

As can be seen in the pictures of the three model municipalities (Havířov, Pustějov and Rychvald), the individual reports may differ slightly. Data is entered into the system manually through the ISPOP application. Even at the present time, human work prevails over reports through paper scales, etc. This system leads to inefficient and slow processing of data for reporting to ISPOP. A possibility to improve processes would be, for example, smart elements in support of sustainable waste management, which are based on the very essence of smart solutions in a wide range of areas, be it technology or everyday life. It is possible to choose the so-called IoT Platform - Internet of Things, which is based on cloud solutions enabling the mutual virtual connection of both things and people. This platform can be used for dynamic and effective planning and direction of waste management not only of the municipality, but as a whole. Individual cities could use IoT to better solve their waste management, connecting all information from the field in real time, and each participant in this solution has their own subject of interest or area on this system, which they can monitor and manage. IoT can be used for waste collection planning, obtaining map data and system routes. This leads to significant savings in time and money, as well as the elimination of human errors.

3 Conclusion

Today's global turbulent environment, which is gripped by the effects of the covid crisis (a strong part of the pandemic begins in China), the energy crisis caused by the conflict in Ukraine, the faster transition to green technologies is largely unpredictable. What is certain, however, is that the volume of waste produced is very high these days. Humanity and waste are two continuous quantities that have been linked together since ancient times.

All human activity generates a significant amount of waste, whether it is generated in agriculture, the industrial sector, services, or in ordinary human life. The connection with consumer life leads to considerable generation of municipal waste. The burden on the environment is gradually increasing, which is not a good business card for us on the planet, nor is it a good legacy for future generations. In order to reduce this burden, a simple thing must be incorporated into the process, namely that the waste will be sorted in a high-quality and efficient way using the most modern technologies. The key institutions responsible for ensuring waste management in the Czech Republic are not only the Ministry of the Environment and the Regions, but also the municipalities, as the responsible authorities as waste generators but also responsible for physical waste management.

Without investments in smart solutions within waste management, which lead to easier fulfillment of the goals set in the waste management hierarchy, cities and municipalities, simply municipalities, cannot effectively manage waste management. After implementing a sufficient amount of smart and sustainable solutions, cities will achieve an increased proportion of sorted waste components, which can subsequently be better sorted and processed, including an increase in the quality of the entire process with a positive impact on the environment. An accompanying fact is also the reduction of expenses on waste management in the form of savings in the management of hitherto inefficient solutions, which lead to the manual filling of reports into the ISPOP information system. These facts lead to a more balanced economic aspect of the entire waste management and a reduction of negative impacts on the environment.

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Implementation of low carbon economy innovations during the transformation of the Moravian-Silesian region

Filip Kempa¹, Roman Kozel²

Abstract. The global transformation of infrastructure and technology to combat climate change requires urgent action. In the age of digital transformation, ICT solutions are the foundation of modern, economically stable societies. With the help of these technologies, services, tasks and products are gradually being transformed in small, medium-sized and large enterprises. This paper deals with information technology innovations that are used in the process of low-carbon economy. The paper briefly introduces the transformation plan and process of the Moravian-Silesian region in the transition to low-carbon resources, which promotes innovation, trends in public research, development and deployment.

Keywords: innovation, low carbon economy, technologies, transformation.

JEL Classification: O13, O32, Q55, Q56

1 Introduction

The gradual transition to low-carbon energy sources and the associated climate change are one of the most pressing challenges of this century worldwide. The main essence of the transition to a low-carbon economy is to reduce greenhouse gas emissions, which are the reason for the deteriorating air quality. (Kempa, 2020)

Reducing greenhouse gas emissions and enhancing their sinks (mitigation) is an integral part of addressing climate change and its negative impacts. Emissions and sinks of the main greenhouse gases are regularly monitored by the UNFCCC through inventories. In the Czech Republic, the responsibility for the proper functioning of the National Inventory System (NIS) lies with the Ministry of the Environment, which has designated the Czech Hydrometeorological Institute as the organisation responsible for

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coordinating the preparation of the inventory and the required data and text outputs. In terms of individual gases, CO₂ is the most important greenhouse gas with a share of 82.7% of total emissions, followed by CH₄ 9.9%, N₂O 4.5% and F-gases 2.9%. The energy sector is the most important category in the inventory, accounting for 72.7% of total GHG emissions, mostly CO₂. (mzp.cz, 2018)

The Moravian-Silesian region has been historically influenced by coal mining and related industries. The region has been undergoing a transformation associated with the gradual reduction of coal mining since the 1990s and is now entering its final stage. The last active mines are being closed and considerable resources and human capacity will be needed to restore the mountain landscape and the economic and social development of the region. The Moravian-Silesian Region is one of 3 Czech coal regions undergoing economic restructuring that will be able to benefit from the new European Fair Transition Mechanism, including the Fair Transition Fund. The Moravian-Silesian Region thus has a real opportunity to influence where the resources for the transformation of coal regions under the Fair Transition Mechanism will be directed. (hrajemskrajem.cz, 2021; msk.cz, 2021)

This paper aims to present the innovation strategy of the Moravian-Silesian Region in the transformation of the region to low-carbon sources. A substantial part of the paper is devoted to the Transformation Plan of the Moravian-Silesian Region. It focuses on 8 thematically focused programmes, which are interrelated, partly overlapping, complementary and creating synergies. Specific objectives are given for all the programmes mentioned. This is followed by a conclusion summarising the article.

2 Innovation management

Innovation means improvement. Major changes or improvements are considered innovation. Closely related to innovation is the concept of creativity or creativity. Innovation must be preceded by some creative activity and creative thinking. Creative activity is called innovation. Innovation without creativity cannot take place. Innovation management deals with the introduction of something new into the functioning and

operation of an organisation/business or into its portfolio of products or services. (chovani.eu, 2018; managementmania.com, 2016)

There is a wide range of policy instruments that support innovation. Strong climate policy is essential to drive innovation in the right direction, but other instruments also play a role and can inadvertently hinder change. (OECD, 2015).

2.1 Innovation Strategy of MSK

The MSK Regional Innovation Strategy builds on and develops the horizontal themes of the Development Strategy of the Moravian-Silesian Region 2019-2027 and the Strategic Development Plan of the City of Ostrava for the period 2017-2023. It defines the areas necessary to meet the definition of "smart specialization", i.e. defines the vision of the regional innovation ecosystem, describes the setting of the EDP ("Entrepreneurial Discovery Process"), identifies the domains of strategic specialization of the MSK, presents the direction of international cooperation, etc.

The size and quality of the region's innovation ecosystem has a direct impact on:

- Growth and innovation in local companies;
- Motivating local residents to start new businesses;
- Willingness of investors to implement activities with high added value in the region;
- The ability of the local economy to create attractive new jobs.

Depending on these factors, and in line with the specialisation of universities and the economy in the Moravian-Silesian Region and taking into account current megatrends, the following areas of smart specialisation have been identified. In terms of application markets, the following 5 domains of specialisation have been formulated in MSK:

- Automotive: Domain focus - automotive components;
- Engineering: Domain focus - special machinery and equipment, mechatronic systems and equipment;
- E-health: Domain focus - medical devices and services;
- Smart-agri: Domain focus - smart machines and devices;

- Hydrogen technology: Domain focus - hydrogen production technology, hydrogen utilization.

In terms of technological areas, the following 5 domains of specialisation have been formulated in MSK:

- Information Technology: Domain focus - digitalization of business processes with emphasis on production;
- Information Technology: Domain focus - data processing activities;
- Technologies for energy production, transmission and storage: Domain Focus - Energy generation, transmission and storage technologies;
- New materials: Domain focus - conductive plastics, new steel properties, new composite materials, circular economy;
- Cultural and creative industries: Domain focus - audiovisual technology and design.

Within the framework of the Regional Innovation Strategy of the MSK, social science disciplines that have an impact on the successful transformation of the region are supported. These activities are reflected across the programmes of the MSK Transformation Plan.

- Participation of residents in the development of their region and community;
- Dialogue between all affected players and communities, fostering effective collaboration and an interdisciplinary approach;
- Regional capacity building and development;
- Identification of talents and regionally specific skills and their development;
- Strengthening the knowledge base for successful transformation;
- Thoughtful strategic planning and evaluation;
- Improving the quality of life in the region and preventing population outflow. (msk.cz, 2021)

3 Transformation plan and transformation of MSK

The architecture of the transformation plan is designed in the form of thematically oriented "programmes". The design of these programmes was based on regional priorities in the region's strategic documents, which overlap and align with the themes to be funded by the Equitable

Transformation Mechanism. The intervention logic, see below, was used to define the programmes and sub-specific objectives. The Transformation Plan consists of 8 thematic programmes that are interlinked, overlapping, complementary and synergistic.

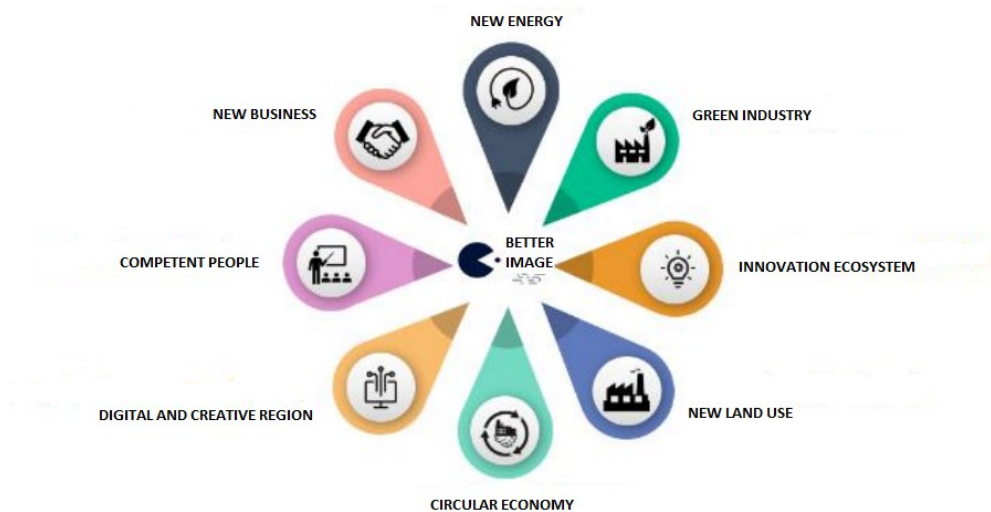


Figure 1 Thematic programmes of the Transformation Plan, Source: msk.cz, 2021.

The proposed programmes are consistent with the Development Strategy of the Moravian-Silesian Region 2019-2027, the Regional Innovation Strategy of the MSK 2021-2027 and the pillars of the Mechanism for Equitable Transformation.

The economic, social and environmental transformation of the region will be a very challenging and costly process. The resources of the Equitable Transformation Mechanism cannot cover these costs to a large extent, making it all the more necessary to target them to the areas of highest priority. It is also important to understand and perceive the overall potential of cohesion policy (Operational Programme 2021-2027) and modernisation instruments (Modernisation Fund, Innovation Fund). A number of topics of importance to the region will be covered by programmes other than the Operational Programme "Fair Transformation". It will thus be efficient and effective to target priorities and measures that standard operational programmes and funds cannot cover, thus creating a competitive advantage through these extraordinary resources.

The content of the proposed 8 programmes reflects the specific needs of the region. Currently, coal mining in the Karviná region is declining and has stopped, which has a great impact on employment not only due to the loss of jobs in the mines, but also in downstream economic chains. Traditional industry in the region is under pressure to decarbonise due to the rising price of emission allowances. Changing the fuel base and moving away from coal poses a huge challenge to the energy and heating industry in the county. There are large sites left to be revitalised after mining.

However, the challenges facing the region are also an opportunity to transform the region, to change the economic structure, develop human capital, support innovation and entrepreneurship, transition the industry to green, introduce the principles of circular economy, massive digitalization or transition to clean energy. The Fair Transformation Mechanism has the ambition to help in particular the economic transformation of the region, which will be affected by the decline of mining and downstream industry.

The transformation and modernisation of industry that has a connection to the region is an opportunity to build on in future development. Industries such as energy, steel, engineering, chemicals, construction materials and automotive will continue to shape the regional economy in the years to come. New industries, innovations and start-ups represent an opportunity to diversify the economic base and help reduce the risk of dependence on dominant industries. (msk.cz, 2021)

3.1 Specific objectives of the proposed programmes

NEW ENERGY

- Increasing the share of low-carbon and renewable energy sources, including investment in clean energy technologies, systems and infrastructure;
- Development of hydrogen technologies in MSK.

NEW LAND USE

- Revitalisation of the mountain area of Karviná and the South;
- Revitalisation of the area after mining and industrial activities for new use.

GREEN INDUSTRY

- Productive investment in traditional industrial enterprises leading the transformation towards a low-carbon economy.

NEW BUSINESS

- Support for SMEs, including start-ups, leading to economic transformation, modernisation, low-carbon economy including the development of smart specialization.

COMPETENT PEOPLE

- Increasing employment and employability of people in the labour market;
- Developing infrastructure to improve access to education, training, entrepreneurship and lifelong learning.

INNOVATION ECOSYSTEM

- Building the innovation ecosystem in MSK with a link to the priority themes of the region's innovation strategy;
- Investments to strengthen capacity and cooperation in research, development and technological innovation.

DIGITAL AND CREATIVE REGION

- Investing in digitalisation, digital innovation and digital connectivity;
- Development of the cultural and creative sector.

CIRCULAR ECONOMY

- Supporting the transition to a circular economy. (msk.cz, 2021)

4 Conclusion

This paper reports on the issue of global warming of the Earth caused mainly by human air pollution. The article focuses specifically on innovations in the field of low-carbon economy that are expected to lead to the European Union's goal of making the entire European Union carbon neutral by 2050 at the latest. The main focus of the article was on the Innovation Strategy of the Moravian-Silesian Region in the transformation of the region to low-carbon sources. Another key part of the paper was a description of the MSK Transformation Plan. The proposed 8 programmes

specific to the needs of the region are part of it. The specific objectives are specifically listed at the end of the paper.

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ICT factors at the national level and their influence in the era of pandemic

Jakub Sieber¹

Abstract. The presented paper describes the role of ICT at the national level. Using the Generalized Linear Model, the work proposes to identify the key predictors of the government's effectiveness. According to the latest data covering the pandemic years the model estimates the significance and relation to government effectiveness in 24 European Union countries. The results of the paper imply that e-government as a tool of national ICT infrastructure helps effective governance and its perception by the individuals.

Keywords: ICT, e-government, digitalization, public services

JEL Classification: O32, O33, H11

1 Introduction

Since Information and communication technologies (ICT) play a significant part in daily life, it also influences government or e-government. To stay up and improve the policy results, service quality, and responsiveness to people that define their efficacy, governments have also been integrating such technology into work procedures. E-government efforts may improve the efficiency of the government in several significant ways, including fostering cross-agency cooperation on difficult problems, encouraging a customer focus for services, and forging partnerships with the private sector. Delay in adopting e-government changes might therefore hinder economic growth in this world that is becoming more competitive and changing quickly. Various levels of such implementation are reported by European nations (Prahono and Elidjen, 2015). Digitization of business processes as well as providing government services through various online platforms remains one of the pillars of the European Union (EU) strategy. In the framework of ICTs, the public sector is implementing a set of theories and practices that call for utilizing commercial and private sector methodologies in the public sector to improve organizational effectiveness and efficiency and so lessen the burden of bureaucracy (Cordella and Bonina, 2012; Cordella and Tempini, 2015). In line with the growing concern about ICT

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dissemination in the public sector, a great number of empirical studies have used a range of approaches to create evidence for the growth of new digitalized public services (Arduini & Zanfei, 2014; Wirtz & Daiser, 2018).

2 E-government as an ICT factor

The use of ICT, particularly the internet, to improve communication between government to consumer (G2C), government to business (G2B), and the international level of cooperation between government to government (G2G), in order to increase efficiency, and effectiveness, transparency and accountability of government implementation may be referred to as e-government, according to several sources (Nurdin et al., 2012; Cordella and Bonina, 2012). According to the OECD (2021) definition, e-government, or referred also to as a digital government can be used in Public Administration Reform due to some reasons mainly improving online access to information and enabling the delivery of services to citizens and businesses in a convenient way. New Public Management (NPM) inspired e-government strategies frequently advocate the use of public sector ICTs as primary tools for reducing the size of government bureaucracy. According to (Cepparulo and Zanfei, 2019) there are various e-services falling under the umbrella term e-government, such as eHealth, eInvoicing, transportation/info mobility, and eProcurement. The study of Cordella and Tempini (2015) provides actual proof that ICTs may support alternative organizational strategies that increase the effectiveness and efficiency of public sector organizations by fostering bureaucratic collaboration. As the authors found in their study in the municipality of Venice, the interdependencies between public administration departments have been redefined because of the Internet Reporting Information System (IRIS). The functional ties and interdependencies between the organizations and their employees have grown stronger. This is the outcome of a new bureaucratic structure that, by automating bureaucratic activities and assisting the professional bureaucracy's work in the participating organizations, more effectively delivers public services through bureaucratic organizations. The brokerage capability of the IRIS system supports these new bureaucratic structures.

3 Methodology

The primary objective of the presented paper is to provide evidence that e-government influences the overall effectiveness and quality of state (national) governance. Therefore, the e-government is examined as one of the predictors of the government quality itself.

Methods used

The methodology of the presented paper follows the method of Nelder and Wedderburn (1972), who developed generalized linear models as a means of combining numerous different statistical models, such as linear regression, logistic regression, and Poisson regression. Each result Y of the dependent variables in a generalized linear model (GLM) is supposed to derive from a specific distribution in the exponential family, a broad category of probability distributions that include, among others, the normal, binomial, Poisson, and gamma distributions. The independent variables, X , determine how much the distribution's mean, μ , changes as a result: (Hastie and Tibshirani, 1990)

$$E(Y|X) = \mu = g^{-1}(X\beta) \quad (1)$$

$$Var(Y|X) = V(g^{-1}(X\beta)) \quad (2)$$

In Eq. 1, where X is the linear predictor, a linear combination of unknown parameters and g is the link function. $E(Y|X)$ is the expected value of Y conditional on X . The variance in this paradigm is often a function of the mean, V (eq. 2). Although it is useful if V derives from the exponential family of distributions, it is also possible that the variance merely depends on the value that was anticipated. Usually, Bayesian, maximum quasi-likelihood, or maximum likelihood approaches are used to estimate the unknown parameters. Three components make up the GLM: a specific distribution for modeling Y chosen from among the exponential families of probability distributions, a linear predictor $\eta=X\beta$, and a link function g . When fitting the model, Newton's approach can be used to get the maximum likelihood estimates, as can an iteratively reweighted least squares algorithm: (Rossi, 2018)

$$\beta^{(t+1)} = \beta^{(t)} + \mathcal{T}^{(-1)}(\beta^{(t)})u(\beta^{(t)}) \quad (3)$$

Where $u(\beta^{(t)})$ is the score function, and $T(\beta^{(t)})$ is observed information matrix. Therefore, the general form of the GLM regression model in the presented paper can be written as:

$$Y = \beta_0 + \beta_i X_i + \beta_{i+1} X_{i+1} \dots + \beta_n X_n + \varepsilon \quad (4)$$

Data and variables description

The selected sample covers all the EU countries, excluding Cyprus, Malta, and Luxembourg. Therefore, the training of the model is according to data of 24 EU member states. In the examined model, the dependent variable is government effectiveness (*govEffect*). Government effectiveness includes opinions on how well public services are provided, how well the civil service is run and how free it is from political influence, how well policies are developed and implemented.

The set of predictors for the GLM model contains six variables. Corruption index (*corruption*); this index is describing the perceived corruption by inhabitants of EU countries according to Nicholas et al. (2022) and OECD (2018) data collected by survey. The lower the index, the more is corruption perceived. Rule of law (*ruleOfLaw*) corresponds to the indicator measuring the extent to which individuals have confidence in justice, sourced from World Justice Project (2022). Regulatory quality (*regulatory*) measures of transparency, civic participation, and government accountability across the life cycle of regulations, data collected from the World Bank (2022). E-government quality (*egovQuality*) index compares and defines the functionality, openness, connectivity, security, and other aspects of national e-government public services (Nicholas et al., 2022; European Commission, 2022a). Digital skills (*digitalSkill*) predictor describes the share of an individual's ability to master digital skills following five dimensions: information, communication, problem-solving, software for content creation, and safety (European Commission, 2022b). Digitalization (*digitalization*) predictor describing the overall level of digitalization and its penetration in the EU country's economy and life (European Commission, 2022b).

4 Results

Table 1 provides a look at the descriptive statistics of the selected predictors and examined dependent variable in GLM regression. Besides the elementary descriptive statistics, there was carried out Shapiro-Wilk Test, with an alpha level of 0.05, confirming the null hypothesis of the normal distribution cannot be rejected, and that the data may be normally distributed. Either the data may be assumed as normally distributed the minimal and maximal values shows that the selected variables may contain outliers, especially when looking at the median value.

Table 1 Descriptive Statistics of the Sample. Source: Own.

Variable	Mean	Median	St. Dev.	Min	Max	Shapiro Wilk Test	p- value SW
govEffect	79.808	81.970	14.475	42.790	99.040	0.937	0.137
corruption	36.125	39.000	14.552	12.000	58.000	0.942	0.180
ruleOfLaw	80.829	83.410	13.795	51.440	100.000	0.941	0.168
regulatory	82.172	84.135	11.156	64.420	99.040	0.933	0.116
egovQuallity	76.667	75.950	13.005	53.400	96.500	0.954	0.325
digitalSkill	48.000	45.750	10.241	30.900	71.400	0.968	0.626
digitalization	70.022	70.185	11.995	42.650	89.980	0.971	0.685

Table 2 compares the null model (H0) to the model with the selected predictors (H1). As the elementary model diagnostics parameters Akaike information criterion (AIC) and Bayes information criterion (BIC) showing, the H1 model might be preferred before H0, as the absolute value is lower in the case of H1. The deviance of GLM regression presented in *Table 2* generalizes the residual sum of squares, in the case of H0, it features only the intercept, as the enter method was used for model building. While using GLM regression, the deviance of $H_0 \neq H_1$, it is possible to assume that predictors in *Table 3* might be considered as model-related to the government effectiveness. According to the predictors' parameters estimations, the predictors *digitalSkill* and *digitalization* are not statistically significant, therefore they can't be incorporated into the model while the dependent variable is represented by government effectiveness. As expected, corruption plays a significant role. As stated before, the corruption index is based on the methodology, where a higher number reflects more satisfaction of surveyed

individuals. Therefore, if there is a positive change in the perception of corruption, the government's effectiveness will respond also in a positive way.

Table 2 Model Summary – Dependent Variable government effectiveness. Source: Own.

Model	Deviance	AIC	BIC	df	X ²	p
H0	4819.28	199.365	201.721	23		
H1	0.239	-26.482	-17.058	17	4819.040	< .001

Table 3 Coefficients of GLM. Source: Own.

Variable	Estimate	St. Coef.	St. Error	t	p-value	95% CI	
						Lower Bound	Upper Bound
(intercept)	-100.801		0.898	-112.28	<.001	-102.561	-99.042
digitalSkill	-1.808e-4	7.0E-05	0.005	-0.037	0.971	-0.010	0.009
corruption	1.007	1.012	0.008	129.698	<.001	0.992	1.022
ruleOfLaw	-1.022	-0.974	0.010	-102.137	<.001	-1.042	-1.003
regulatory	-1.001	-0.771	0.009	-113.569	<.001	-1.018	-0.984
egovQuallity	4.034	3.624	0.022	184.949	<.001	3.991	4.077
digitalization	-0.002	-0.002	0.003	-0.568	0.577	-0.008	0.005

According to the estimated coefficient and confidence interval (CI), it might be modeled with an almost equal ratio of units 1:1. Similarly, also the predictor *ruleOfLaw* shows the same trend. When there is a change in one unit of confidence in justice, it leads to a decrease in government effectiveness. In this case, the CI shows with a 95% probability, that the change might be more than one unit in the dependent variable. The same relationship is possible to observe also in predictor *regulatory*. The predictor *egovQuallity* is showing the highest positive influence on the government's effectiveness, meaning that the influence of the e-governments functionalities, security, and other perks might influence the overall effectiveness of the member state governments in the EU.

After designing the model and confirming that e-government plays a significant role, there is performed visual analysis and comparison of the e-government quality predictor as stated by European Commission (2022a) and European Government Quality Index EQI formulated by Nicholas et al. (2021). There was assigned a numeric value to e-government quality, overperforming =3, on-track=2, underperforming or unexploited =1, while

the EQI index was maintained as in the source, stating the index value of EQI comparing the overall ability of the government to face the issues.

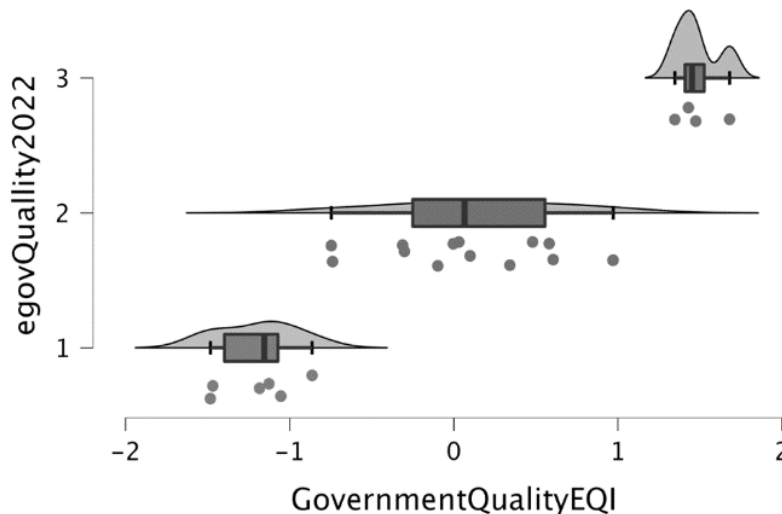


Figure 6 Visual analysis of EU states comparing the government and e-government qualities. Source: Own.

It is possible to observe in *Figure 1*, that EU member states governments with the highest level of e-government services (Netherlands, Sweden, Finland, and Denmark) are perceived as more effective and have much smaller variability in their EQI as represented by the upper box plot presented in Fig.1. Also, it can be observed, that countries with the middle quality of e-government do not exceed the EQI in the interval $<-1;+1>$, while their dispersion is the highest among all three observed groups by e-government quality.

5 Conclusion

The presented paper provides a look at the usage of e-government and other selected predictors and their influence on overall government effectiveness. The elementary descriptive statistics of examined EU member states provide and support the previous evidence of Prahono and Elidjen (2015), that the penetration and implementation of e-government services are still various in the EU. In GLM regression it was confirmed that the factor of ICT usage by the government, in this case, the service *e-government*, influences in a positive way the effectiveness of the governance from the examined variables by most. This is in line with the results of Cordella and Tempini (2015), that the level of ICT adoption may increase the effectiveness

and efficiency of public sector organizations. In this case, the e-government and its infrastructure play a major role, while the digitalization level or general digital skills of an individual's role in the government's effectiveness can't be confirmed.

Future research should be aimed at the analysis of more predictors, at the regional level to explain either the implementation of the e-government services or the effectiveness of the government (municipality) itself while using different methods of examining the relationships such as non-parametric methods or machine learning algorithms, as decision trees to avoid the limitations of the distribution of the variables.

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Procurement of ICT in conditions of Slovak Republic

Martin Staško¹

Abstract. The constant progress in technology and the increasingly widespread use of the Internet have led to increased attention to the ICT sector for several years. This sector plays an important role not only for people, but also for businesses and public administration. The presented paper deals with the investigation of the influence of selected variables in the process of public procurement of ICT in the form of notebooks in Slovakia. The result of the investigation is the identification of factors, that increase the chance of success in the public procurement process from the point of view of the involved companies with the aim of minimizing the costs of lost opportunities.

Keywords: public procurement, ICT, price, cost, design of experiment.

JEL Classification: O32, O33, H11

1 Introduction

The sector of information and communication technologies (hereinafter referred to as ICT) has received increased attention in the world for many years. Its positive impact on the economic development of countries brings this industry to the forefront of the interest of many states, which also improves their competitiveness. If we look at the ICT sector from an economic point of view, then in the case of negative economic developments in the world, countries started to deal with this sector more and more intensively, as it brings a positive impact on the economic growth of the country. Although it is difficult to exactly quantify the contribution of the ICT sector to the creation of the gross domestic product (hereinafter referred to as GDP), many studies point to a close connection between investments in ICT and the increase in GDP (Frendáková, 2011).

Nowadays, the control of ICT has become an essential part of the successful establishment not only of an individual on the labor market, but also of a company in a competitive environment, as well as a way to improve the conditions of public institutions and the competitiveness of the country itself.

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Currently, practically the only standardized institution of the supply chain of the procurement of goods and services between the public and business sectors is the public procurement process, in which ICT plays an important role. ICT is considered to be the most frequently procured goods in the public procurement process in Slovakia (Šípoš, Klátik, 2013).

Based on this fact, the subject of the research of the presented paper is the public procurement process of ICT in Slovakia. We used an electronic contracting system for the selected type of goods, i.e. for laptops, or notebooks. The public procurement process itself, compared to the private sector, provides publicly available data, which was the main reason for its selection.

The main goal of the presented paper is to investigate the influence of selected variables appearing in the process of public procurement of ICT in the form of notebooks in Slovakia. In order to fulfill the main objective of the presented paper, the basic set of data consists of a total of 300 contracts for the procurement of laptops, or notebooks. Since the variety of laptops is very wide, we decided to ensure their kinship by pre-defining the technical parameters of the investigated type of computing technology. With this step, we subsequently eliminated differences in the procurement of ICT in the form of notebooks.

2 Methodology

In order to ensure the quality of decision-making by business entities, we used the method of planned experiment (Design of Experiment - hereinafter referred to as DoE) in the presented paper. The basis of the theory of the experiment is the mathematical model of the experiment, which is based on abstraction, experience and exact measurement results and is written in mathematical language (Miller, 2010). The plan of experiments with the help of DoE makes it possible to classify the factors into significant and less significant, taking into account the surrounding conditions, which form an integral part of the process. It allows to obtain information about the mutually controlled influence of individual factors at the input and thereby to actually get to know the properties of the subject of experimentation better (Allen, 2019).

In our case, the best suitable experiment seemed to be the use of a factorial two-level experiment, which can examine several factors at once. In the

beginning, we chose a total of 8 factors, with the aim of investigating their effects on the chosen response. We quantified the total number of measurements based on the 2^k relationship, where "k" represents the number of factors. Since a large number of measurements would not be possible due to the lack of time, capacity and resources, we decided to use a partial (one-eighth - 2^{8-3}) factorial design of the experiment with 32 measurements. Despite the reduced number of measurements, we were able to investigate selected interactions between selected variables.

3 Factors influencing the success in the public procurement process of ICT

A necessary step for the implementation of the planned experiment is to choose such input variables, within which it is possible to predict their influence on the output variable, i.e. response and which can be measured at the same time. As already mentioned, the result was the choice of eight factors, the selection of which was based on the results of an ex-post analysis of already implemented public procurements in the field of ICT in the form of notebooks in Slovakia.

In the ex-post analysis, we worked with a number of variables in order to achieve the most accurate results possible. Due to the limitation of the text in the presented paper, we present an ex-post analysis of only a few selected indicators.

One of the subjects of interest in the ex-post analysis was to monitor the price change with the simultaneous change in the number of procured ICT pieces. For the needs of the experiment, it was necessary to categorize the number of pieces within individual orders into two main groups. Due to the fact, that in more than half of the public contracts, only one piece of notebook (hereafter referred to as NB) was procured, we decided to divide the number of procured pieces into a group with one piece of NB and contracts with two or more procured pieces NB. With such a breakdown, it turned out, that the average unit price of notebook of multi-piece orders is lower, than in the case of single-piece orders.

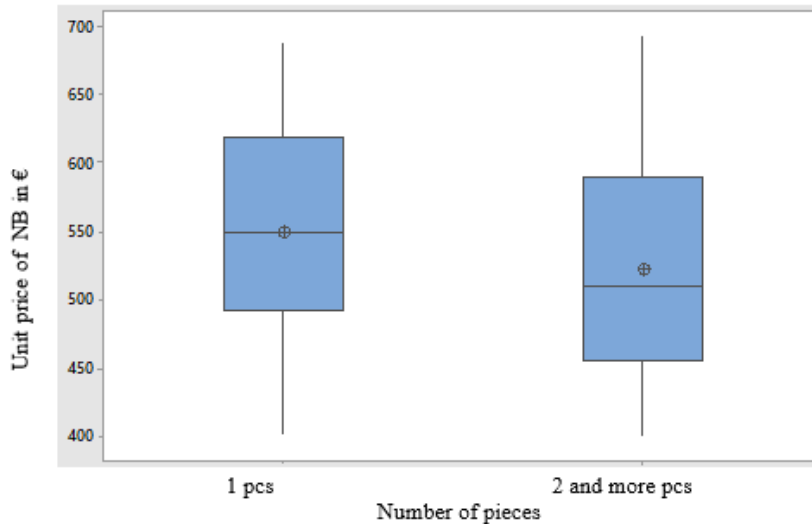


Figure 1 Box plot of unit price NB and number of pieces, Source: own research.

The basic assumption for the implementation of a public contract is the submission of an offer from at least one applicant. The lower limit of the number of applicants is therefore limited to one, while the upper limit practically does not exist. In this context, we had contracts with the number of applicants from 1 to 13 in the research set.

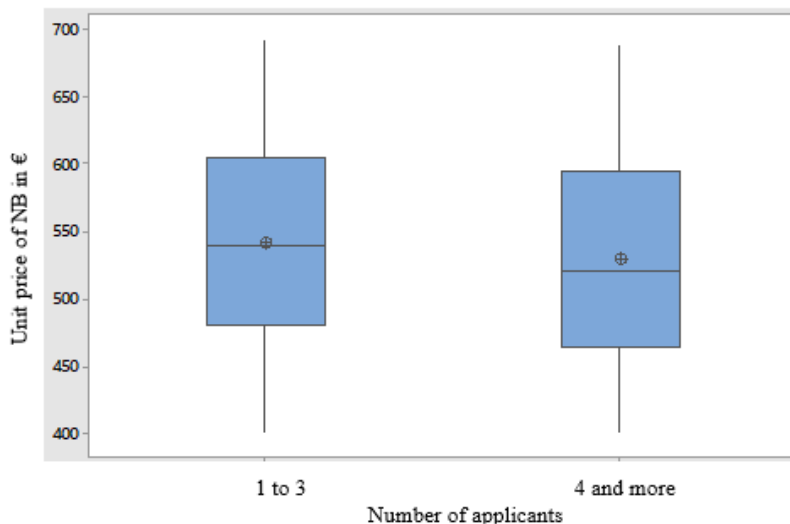


Figure 2 Box plot of unit price NB and number of applicants, Source: own research.

Again, for the purposes of conducting the experiment, we divided the file into approximately two equal parts, based on the number of applicants within one contract. Subsequently, we examined the average prices of notebooks in the

two groups of orders created. It turned out, that a set of contracts with one to three applicants recorded a higher average unit price of laptops, compared to contracts with four or more applicants.

An important attribute of public procurement through the electronic marketplace system is the auction. In the case of an electronic auction, the public contracting authority will invite the first three applicants with the most favorable offers to modify their offers in this way. In the research set, the majority of public contracting authorities used this option, which was logically reflected in the final price of notebooks. As we see in fig. 3, the group of public procurements with an auction realized a lower average unit price of notebooks, compared to the group of orders for which the auction was not possible.

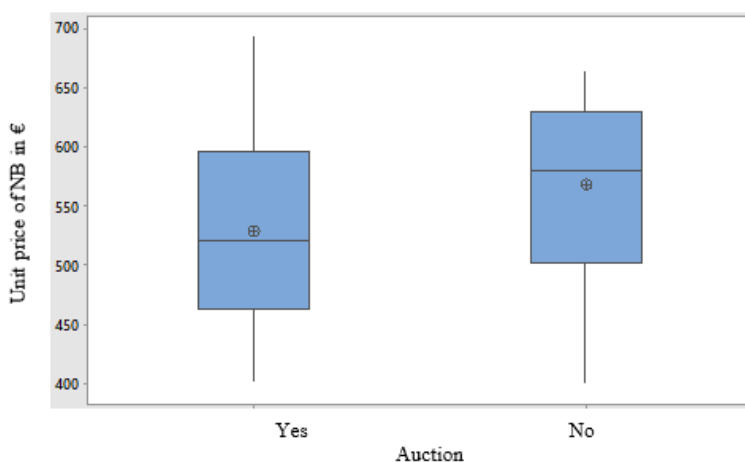


Figure 3 Box plot of unit price NB and auction, Source: own research.

Despite the fact, that the effort was to work with as many variables as possible, despite the increasing complexity of the whole experiment, it was not possible. For this reason, by gradually eliminating the least causally significant factors, we worked on a set of eight factors, on the basis of which we compiled an experiment plan consisting of factors, that are described in more detail in Table 1, including their lower (-1) and upper levels (1).

The MiniTab program generated random combinations of the values of the selected factors within 32 measurements. Based on the factor plan, we sorted orders from the set of implemented ICT public procurements in the form of laptops according to the generated combinations of the values of the selected factors. The result of this selection was a set of 32 successful applicants, whose orders met the combinations of factor values from the experiment

plan. Subsequently, we simulated conditions of the electronic marketplace system in order to obtain feedback from entities, that have already used the public procurement process in the past for the purpose of selling ICT in the form of notebooks.

Table 1 Identification of factors for NB, Source: own research.

Factor	Description of the factor	Lower level (-1)	Upper level (1)
<i>Institution</i>	Type of contracting authority by source of funding	MB (municipal budget)	SB (state budget)
<i>Location</i>	The same territorial region of the contracting authority and the applicant	DR (different region)	SR (same region)
<i>Number of pieces</i>	Number of desktops	1 (1 pcs)	3 (2 and more pcs)
<i>Auction</i>	Possibility of electronic auction	Y (Yes)	N (No)
<i>P1</i>	Technical parameter - processor type	i3	i5
<i>P2</i>	Technical parameter – RAM size	4GB	8GB
<i>Delivery of goods</i>	Number of days needed for delivery of goods	3 (1 to 4 days)	5 (5 and more days)
<i>Estimated value</i>	Maximum amount of public financial resources	400 (up to 499 Eur)	600 (500 - 600 Eur)

To interpret the results of the implemented experiment in the case of notebooks, we used the Pareto diagram to identify the significance of individual factors. In general, the Pareto diagram shows which of the monitored factors are significant and which are not. This is not a classic Pareto diagram, but the MiniTab program uses the principle of Pareto analysis to determine statistically significant factors, which it subsequently shows in the form shown in figure 4. The absolute values of the effects are shown on the x-axis, and individual factors, including their combinations, are shown on the y-axis. The red vertical line represents the chosen significance level $\alpha = 0.05$. We consider all factors that exceed this critical threshold to be statistically significant in the context of the experiment.

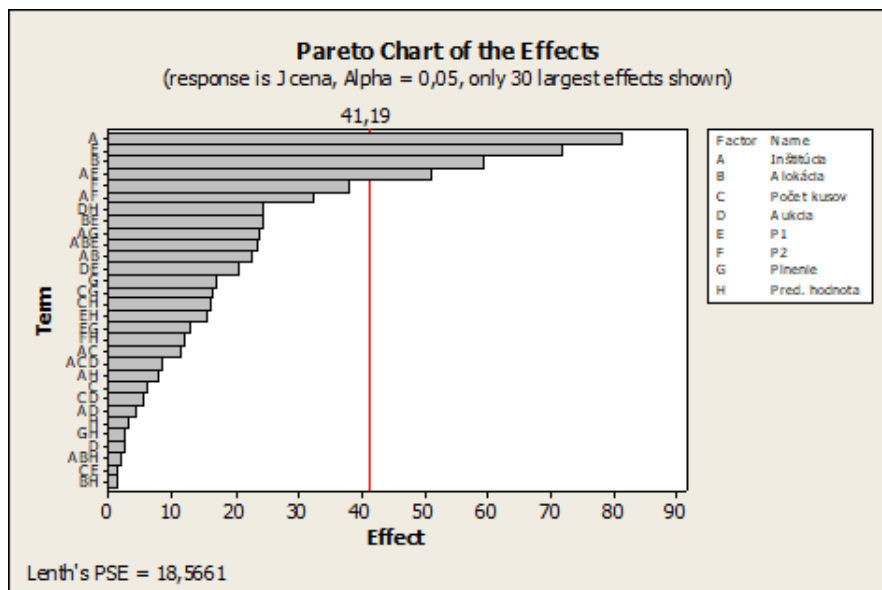


Figure 12 Pareto Chart of the Effects for NB, Source: own research.

Based on the performed Pareto analysis, we conclude that the following factors can be considered as important:

- type of institution,
- technical parameter P1 – type of processor,
- allocation – same affiliation of the contracting authority and the successful applicant by region,
- institution and technical parameter P2, i.e. combination of factors.

The other monitored factors and their combinations in the case of notebooks are below the selected significance threshold, so we consider them statistically insignificant.

4 Conclusion

We decided to use the method of the planned experiment for the purpose of investigating the influence of variables appearing in the process of public procurement of ICT in the form of notebooks in Slovakia. The primary goal of the experiment was to determine which variables have the most significant impact on the public procurement process. Our intention was, based on a

model case, to provide business entities with guidance on how to proceed most efficiently in the public procurement process for the procurement of ICT in the form of laptops in order to reduce the costs of lost opportunities.

After statistical data processing through the MiniTab program, we state, that in order to minimize the costs of lost opportunities, companies should focus on those factors that increase the chance of success in the public procurement process. Specifically, business entities appearing in the given process should focus on the type of institution, parameter P1, allocation and combination of factors type of institution and parameter P1. These factors have a statistically significant and positive effect on the unit price of procured notebooks.

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INFORMATION SECURITY

Seventeen years with the key ISO/IEC 27k family of standards

Petr Doucek¹, Lea Nedomová^{1,2}, Milos Maryska³

Abstract. This paper is devoted to the one of the most important part of daily life in all companies, especially in current Covid-19 time. This part is Risk Management. Paper is describing Risk Management discipline itself with focus on the risk in the area of Information Technology (IT). We analyzed key processes, factors and risks and best practices, which have to be considered into account when IT risk management is introduced into company during Implementation project. This paper does not describe any technology supporting risk management.

Keywords: Risk Management, Information Technology, Risk Process, Operation Risks, Best Practice.

JEL Classification: G32; D8

1 Introduction

The current penetration of information systems into the economy, including its current globalization, practically makes all our activities critically dependent on information systems. Dependence on digital data also requires to trust them. Users' trust in the data in information systems is one of the fundamental features of the security of information systems (Dalal et al., 2021). Cyberspace action associated with the war in Ukraine clearly show the importance of protecting data. Since there are no borders in cyberspace, any attack between the parties to the conflict has an impact on their surroundings, allies and sympathizers. There is a reason why the National Cyber and Information Security Agency (2022) issues a warning about cyber-attacks against authorities and organizations in the Czech Republic.

The basic security parameters include confidentiality, integrity and availability (Jirásek, 2015). One aspect of the security of information systems is their state, which means information about the level of the basic security components. Dynamic information about the development of security applies

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to the information security management system (ISMS). How information security management systems keep developing, especially in the commercial sector and the public and state administration sector. Commercial companies, especially multinational ones, pay great attention to security management systems. Security requirements keep increasing and so does the financial volume of services provide in this area. The global cyber security market is projected to grow from USD 155.83 billion in 2022 to USD 376.32 billion by 2029, exhibiting a CAGR of 13.4 % (Fortune, 2022). It is obvious that the volume of security services will keep increasing, but its structure will be changing as the portfolio of threats arising from new applied technologies will change.

The aim of this article is to recapitulate and evaluate the development and history of the core of ISO/IEC 27000 standards and to present, based on our analysis, the opportunities that the new version of the ISO/IEC 27002:2022 standard provides.

2 Methodology

The protection of data in information systems pretty much comes from the time when these systems left the military environment and widely expanded to the business environment, especially in the 1960s. This is why, we must go back all the way to this time period for these historical documents.

We mostly analyzed different documents as part of the methodology we used to prepare information for this article. First, we focused on the security evaluation systems created in the United States, Canada and the then-emerging European Economic Area (European Commission, 1992; US Department of Defense, 1985) and then on the documents of the British Standards Institution. Finally, we focused on the ISO/IEC 27k family of standards. Based on our analysis of these documents, we have formulated the results mentioned below.

3 Results

The concepts of information security management systems stem from product security evaluation systems – TCSEC (Trusted Computer Security

Evaluation Criteria) and ITSEC (Information Technology Security Evaluation Criteria).

Their disadvantage was that they focused on a one-off product security evaluation and not on the development of the security management system. This change, i.e., the possibility to manage the properties of the information system, including its security, was finally brought about by a number of British national standards BS 7799. This original standard was divided into three parts, which became the basis of the ISO/IEC 17799 standard for the information security management system and the ISO/IEC TR 13335 standard for risk management. ISO/IEC 17799–1,2 standards laid the foundation for security management in organizations and made it available to the general business community.

The next step included the reorganization of ISO standards. The main idea was to create a clear concept (clear orders/families) of standards for various areas such as information security management, social responsibility, risk management, etc.

The second, truly revolutionary, change was the transfer of the logic of these standards to Deming's PDCA (Deming, 1982) model to ensure the permanent control and improvement of management systems, including information security management systems. Table 1 shows the historical development of the ISO/IEC 27k family of standards.

Table 1 The historical development of the core of ISO/IEC 27000 standards
(authors)

Year	ISMS vocabulary	ISMS requirements	Set of procedures	ISMS implementation	Effectiveness measuring	Risk management	Certification scheme	ISMS audit
1995			BS 7799					
1996	ISO/IEC TR 13335-1							
1997	ISO/IEC TR 13335-2							
1998						ISO/IEC TR 13335-3	c:cure	
1999		BS 7799-2	BS 7799-1				EA7/03	
2000			ISO/IEC 17799			ISO/IEC TR 13335-4		
2001						ISO/IEC TR 13335-5		

Seventeen years with the key ISO/IEC 27k family of standards

Year	ISMS vocabulary	ISMS requirements	Set of procedures	ISMS implementation	Effectiveness measuring	Risk management	Certification scheme	ISMS audit
2002		BS 7799-2 v2						
2004	ISO/IEC 13335-1							
2005		ISO/IEC 27001	ISO/IEC 17799 v2					
2006						BS 7799-3		
2007			ISO/IEC 27002				ISO/IEC 27006	
2008						ISO/IEC 27005		
2009	ISO/IEC 27000				ISO/IEC 27004			
2010				ISO/IEC 27003				
2011						ISO/IEC 27005 v2		ISO/IEC 27007 ISO/IEC TR 27008
2012			ISO/IEC 27002 v2					
2013	ISO/IEC 27000 v3	ISO/IEC 27001 v2					ISO/IEC 27006 v2	
2014								
2015							ISO/IEC 27006 v3	
2016	ISO/IEC 27000 v4				ISO/IEC 27004			
2017				ISO/IEC 27003				
2018		ISO/IEC 27001 v3				ISO/IEC 27005 v3		
2019								ISO/IEC TS 27008
2020								ISO/IEC 27007
2021								
2022			ISO/IEC 27002 v3					
2023		ISO/IEC 27001 v3				ISO/IEC 27005 v4		

The ISO/IEC 27k family of standards is currently an effective tool for managing information security in organizations (Doucek, 2019). Their advantage is that they provide a consistent view of business security issues. An advantage also becomes a risk because the system of protection and

measures to increase security are also known to potential hackers. The advantage of the standard is that specific measures are listed in the standard in general, but their specific implementation depends on the security manager in a particular organization. Currently, the ISO/IEC 27k family of standards includes around 50 different standards. Its core is shown in Table 2.

Table 2 The core of the ISO/IEC 27000 family of standards

ISO/IEC 27000 Series	
27000:2018	Information security management system – Overview and vocabulary
27001:2013	Information security management system – Requirements
27002:2022	Information Security, cybersecurity and privacy protection – Information Security controls
27003:2017	Information security management systems – Guidance
27004:2016	Information security management – Monitoring, measurement, analysis and evaluation
27005:2018	Information security management
27006:2015	Requirements for the accreditation of bodies providing certification of information security management systems
27007:2020	Guidelines for information security management systems auditing
TR 27008:2019	Guidelines for assessment of information security controls

The whole family of standards keeps gradually evolving; new standards responding to emerging groups of threats are added, e.g., the ISO/IEC 27100 family of standards that deals with cybersecurity, existing standards are modified and improved and old unused standards are repealed (ISO/IEC 27015:2012, repealed in 2017).

Nevertheless, ISO/IEC 27001 and ISO/IEC 27002 standards continue to be the basis. The ISO/IEC 27001:2013 standard divides business information security into the following areas (Figure 1).

This article also briefly describes how the ISO/ IEC 27002 standard has changed in its version from the year 2022:

- 1) the title has been modified;
- 2) the structure of the document has been changed, presenting the controls using a simple taxonomy and associated attributes;
- 3) some controls have been merged, some deleted and several new controls have been introduced. The complete correspondence can be found in Annex B (ISO/IEC 27002:2022).

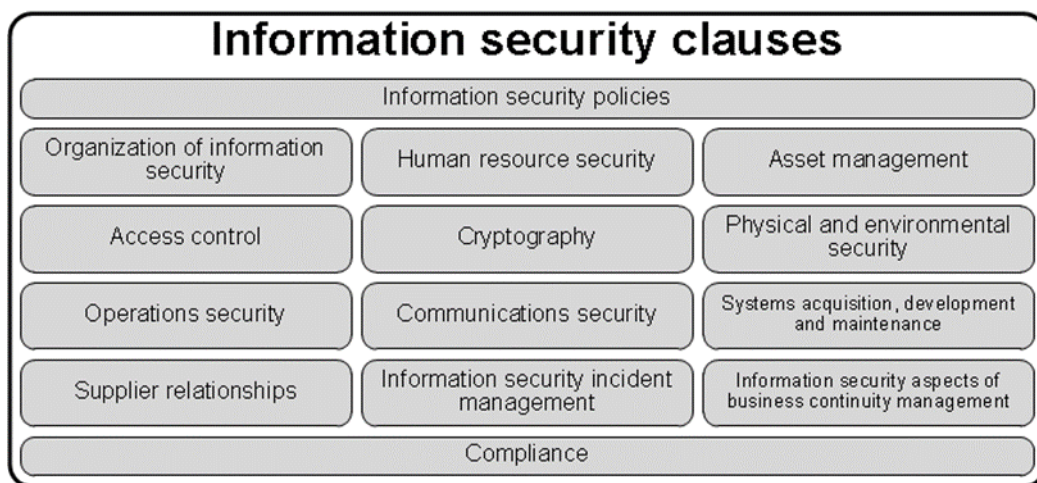


Figure 1 Information security areas according to ISO/IEC 27001:2013
source:(27001-3)

Ad 1) The change in the name of the standard seems insignificant, but it represents an important declaration of the content change, where the authors look for a way to unify controls for both information security and cybersecurity (ISO/IEC 27100 family of standards) and add the protection of privacy (27701:2019).

Ad 2) The layout of the standard has also improved in terms of individual controls. The layout for each control contains the following:

- Control title: Short name of the control;
- Attribute table: A table shows the value(s) of each attribute for the given control;

Example for control “Policies for Information Security”

Table 3 Attribute table for control „Policies for Information Security“

Control type	Information security properties	Cybersecurity concepts	Operational capabilities	Security domains
#Preventive	#Confidentiality#Integrity#Availability	#Identify	#Governance	#Governance_and_Eco-system #Resilience

- Control: What the control is.

Example: Information security policy and topic-specific policies should be defined, approved by management, published, communicated to, and

acknowledged by relevant personnel and relevant interested parties, and reviewed at planned intervals and if significant changes occur.

- Purpose: Why the control should be implemented.
- Guidance: How the control should be implemented.
- Other information: Explanatory text or references to other related documents.

Subheadings are used in the guidance text for some controls to aid readability where guidance is lengthy and addresses multiple topics. Such headings are not necessarily used in all guidance text (ISO/IEC 27002:2022).

Ad 3) The map between the areas of information security, which was respected in ISO/IEC 27001:2013 and to which ISO/IEC 27002:2013 provided controls, is very important. This map makes it possible for organizations to switch from ISO/IEC 27001:2013 certification to ISO/IEC 27001:2022 certification without any major problems.

4 Conclusion

The new ISO/IEC 27002:2022 standard represents a significant potential for the development of business information security management. Its main advantage is that it integrates controls from information security, cybersecurity and privacy protection. Another advantage is that it clearly describes the structure of all controls – their names, definitions and links to other controls.

The change and new issue of the ISO/IEC 27001 standard in the near future will be the next inherent step, which will create a consistent framework for managing business information security in organizations.

Acknowledgement

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Safety Standards for Real Time Control

Roman Danel¹

Abstract. This article analyses requirements for real time control. The article provides comprehensive overview of real time operating systems (RTOS), their classification and criteria for selection. Safety standards for critical systems are described.

Keywords: real-time operating system, soft real time, hard real time, safety standards, IEC 61508, SIL

JEL Classification: D8

1 Introduction

Enterprise information systems for production management are referred to by the acronym MES (Manufacturing Execution System) and together with ERP (Enterprise Resource Planning) it is among the most frequently used corporate information systems. In the era of Industry 4.0, the use of an MES system is a necessity for manufacturing companies. However, it is necessary to emphasize that from the point of view of the control, MES with minor exceptions, does not contain the functions of direct control of technological processes. MES systems function primarily as indirect control – as support for human control. This already follows from the list of essential functions of the MES system, according to the definition of the MESA organization: Data collection and acquisition; Performance analysis; Product traceability and genealogy; Scheduling; Document management; Flow of products and batches; Personnel management; Quality management; Management of preventive and curative maintenance; Resource management; Process management.

Distributed applications are mostly used for real direct control of technological processes and machines. If we need to ensure real-time control, such systems must meet certain requirements for accuracy, speed, reliability and also safety. Real-time control is divided into soft real time, hard real time and critical real time systems. In the case of soft real time systems, it is required that the system reacts to changes and events in real time - non-compliance with the time limit for responding to an event leads to a

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deterioration in the quality of services. An example of such an application is, for example, a video stream from cameras or reading data from a CD/DVD. In case of hard real time, non-compliance with the time limit for reaction to an event can cause a serious error or system failure, in case of critical real time system, non-compliance with the reaction time can cause a crash or threat to people's life. In Hard Real Time systems, system responses in the range of microseconds are needed, which cannot be achieved using conventional operating systems, where the application programmer has no control over task priority management (task priority is managed by the process scheduler in the operating system core). Therefore, a special category of operating systems - Real Time Operating Systems (RTOS) - was created for the needs of real-time control.

A detailed description of the basic concepts of RTOS, kernel construction, resource sharing issues, communication between processes and memory management is given by Cooling [1]. The same author also published in [2] the principles of software engineering in the creation of real time applications. In the book [3], Li analyses RTOS concepts for embedded systems. The paper [4] discusses the importance of RTOS over generic purpose operating system, the pros and cons of using RTOS for microcontroller system development, and the benchmarking methods used for RTOS.

2 RTOS overview and selection criteria

There are many RTOSs today, and some of them are specialized for certain types of tasks [5].

RTOS can be divided according to the method of internal management into:

- RTOS controlled by time (polling) – MARS
- RTOS controlled by events (interrupts) - QNX

Another classification of RTOS is by core solution:

- Kernel in the form of an extra-code library - VxWorks, eCos
- Standalone kernel - QNX, OS/9

According to the degree of compatibility, we divide RTOS into:

- Systems with their own set of standalone functions – Green Hills
- POSIX compliant systems – QNX, RTLinux, Windows CE

Classification of RTOS according to distribution method:

- Commercial (proprietary) systems
- Open-source systems - Zephyr
- Free RTOS – FreeRTOS, OpenRTOS, SafeRTOS

Table1 The mostn often used RTOS

Operating system	Producer	Homepage	Note
RT Linux		http://cs.uccs.edu/~cchow/pub/rtl/doc/html/GettingStarted/	
RTAI	University of Milano, Italy	https://www.rtai.org/	Dual kernel approach, design goal: lowest latencies
ENEA OSE	ENEA AB	https://www.enea.com/products-services/operating-systems/enea-ose	Proprietary
LynxOS	Lynx Software Technologies	http://www.lynx.com	Proprietary; LINUX-like; LynxOS-178 for Critical systems
VxWorks	Wind River Inc.	https://www.windriver.com/products/vxworks/	Proprietary
INTEGRITY	Green Hills software	https://www.ghs.com/products/rtos/integrity.html	Proprietary, for Critical systems
RTX64	IntervalZero	https://www.intervalzero.com/en-products/en-rtx64/	real-time operating system extension to Windows, 90-denní trial
Xenomai		www.xenomai.org	Similar to RTAI; abstract RTOS kernel; Free
Real-Time Linux	Linux Foundation	https://wiki.linuxfoundation.org/realtime/start	PREEMPT_RT patch for Linux distro
embOS	German company Segger	https://www.segger.com/products/rtos/embos/	Focus on industrial and automotive; proprietary
Keil RTX	ARM	https://www.keil.com/arm/rl-arm/kernel.asp	Free; for ARM

			and Cortex
QNX Neutrino	Canadian company QNX Software Systems	https://blackberry.qnx.com/en	Proprietary; microkernel; UNIX-like
Zephyr	Wind River Rocket	https://www.zephyrproject.org/	Open Source – Apache licence
TI RTOS	Texas Instruments	https://www.ti.com/tool/TI-RTOS-MCU	For embedded systems and digital signal processors
FreeRTOS		https://www.freertos.org/	MIT licence
Mbed OS	ARM	https://www.arm.com/products/development-tools/embedded-and-software/mbed-os	Free, open source, for IoT
PikeOS	SYSGO GmbH	https://www.sysgo.com/pikeos	Embedded, IoT
Sciopta	SCIOPTA Germany	https://www.sciopta.com/safetykrn/index.html	Message based RTOS for embedded devices
Azure RTOS	Microsoft	https://azure.microsoft.com/en-us/products/rtos/	For 32-bit embedded devices

Each application demands a specialized set of requirements and to meet these requirements the designer needs to select the RTOS, which meets the desired requirements [6]. We can select a suitable RTOS for a specific application according to the following criteria:

- What functions does it contain?
- What is the guaranteed lowest reaction time of the system?
- Price
- What middleware is available?
- Legal aspects
- What ecosystem does the manufacturer offer? (Monitoring tools, superstructures, administration...)
- References
- What hardware requirements does the system have? (RAM, code run efficiency, memory load at runtime...)
- What is the kernel architecture? (Microkernel, hybrid, monolithic kernel...)
- How does the system solve Priority inversion?

- How does the system work with memory? (Does it contain Memory Management Unit?)
- How are applications programmed?
- How does the system handle interrupt priority relative to a critical task?

Note. Priority inversion is a state when a process with low priority allocates exclusive access to a resource, but is not executed due to low priority; real-time high priority process is executed frequently but cannot continue because it is waiting to release a resource allocated by a blocked low-priority process.

For low-cost solutions, built on cheap System on Chip (SoC) solutions, such as Arduino, esp8266, Raspberry, the Super Loop approach is used (Fig. 1).

Super Loop

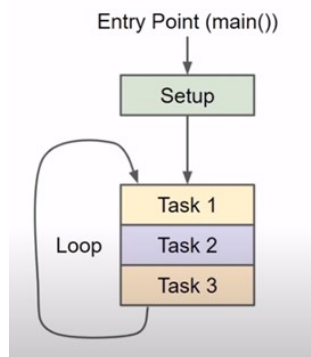


Figure 7 Super loop approach, Source: [7]

After the system starts, it executes the Setup function once, which contains the configuration and initialization of the system, and then enters an infinite loop, which periodically performs the main task. The advantage of such a solution is simplicity, and therefore easy and controllable application development. The disadvantage is that some operations, such as reading data from sensors, can take some time, and by sequentially chaining such activities, the system ceases to meet the requirements for real time response.

A classic RTOS must therefore be able to perform several tasks in parallel (Fig. 2).

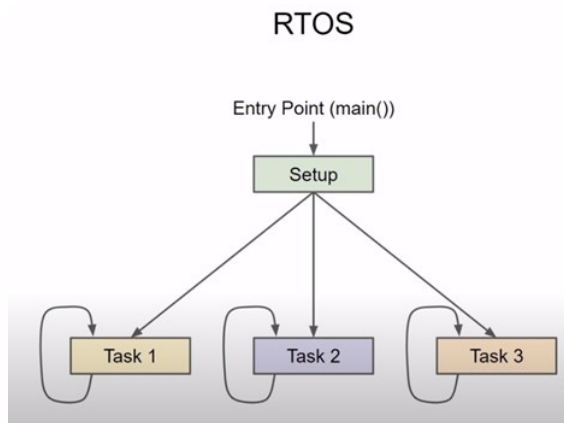


Figure 8 Parallel task approach, Source: [7]

The disadvantage of this approach is the need to solve synchronization between tasks, mutual communication and especially the prevention of deadlocks.

For systems that are to fall into the "Critical real time systems" category, it must be possible to write a task that will be prioritized and uninterruptible. RTOS systems in this category, such as Green Hill INTEGRITY, have the option to disable interrupt handling so that this activity does not slow down the main control task.

3 Safety Standards

Real time systems, and here we mean the entire control system (hardware, operating system and applications), are demanding to ensure safety. There are several standards that define safety requirements, and control system builders can have their solutions certified to these standards. An overview of safety standards for different areas of industry is given in Table 2.

Table 2 The most often used RTOS

Standard	Description
IEC 61508	Safety standard for electrical and electronic devices – defines SIL (Safety Integrity Level); safety life cycle; criteria for software testing
ISO 26262	Standard for automotive; Road Vehicles – Functional Safety
IEC 62304	Medical devices
DO-178x	Aerospace; ,Software Considerations in Airborne Systems and Equipment Certification'; 5 levels of ,failure conditions'; 5 levels of ,design assurance' (A to E); DO-254 - Design Assurance Guidance for Airborne Electronic Hardware
IEC 61511	Safety instrumented systems for the process industry sector
IEC 61513	Nuclear industry
IEC 62061	Safety of machinery
IEC 60730	Safety Standard for Household Appliances
ISO 15408	Common Criteria for Information Technology Security Evaluation

Standard IEC 61508 defines four level of SIL (Safety Integrity Level) - from level 0 to level 4, which means the most security of the system:

- SIL 1 – standard safety
- SIL 2 – requirement for system self-diagnosis, documentation
- SIL 3 – the requirement for the system to operate in the event of failure of individual devices - redundancy
- SIL 4 – at least triple redundancy

There are several methods for determining what level of SIL is necessary for a particular control system, for example:

- Risk matrices
- Risk graphs
- Layers of protection analysis (LOPA)

4 Recommendations for creating Real Time applications

Based on best practices, the following recommendations can be made for creating real-time applications:

- Minimize the number of aperiodic tasks in design
- Use polling for signals instead of interrupts
- ISR (Interrupt Service Routine) – as short as possible
- Keep processor utilisation as low as possible
- Measure the actual spare time so you know what is really happening

Hide:

- Task location
- CPU type and location
- Network protocol aspects
- Signal handling features

Consider:

- Synchronisation of operations
- Addressing errors
- Data errors
- Message timing errors
- Consistency of data across the system

5 Case Study

As a case study of the real time control, we can mention rover Perseverance working on Mars. This vehicle works in autonomous mode, as control command from the Earth comes with significant delays. NASA used for the rover control two computers with processor PowerPC 700 running on 200 MHz with 256 MB RAM memory and 2 GB flash memory. As the operating system RTEMS 4.5.0 has been used. RTEMS is an open-source real time operating system having compliance with IEC 61508 and DO-178B standards. [8]

6 Conclusion

The article contains an overview of real-time operating systems, their categorization and main security standards. Creating real-time control applications for hard real-time and critical systems is an area that requires specific technical resources and knowledge.

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EDS security

Jan Ministr¹

Abstract. The epidemic caused by disease COVID–19 in 2020 influenced life worldwide. Companies and private sector were closed during several weeks/months, public administration limited their own services and opening hours. Due to ongoing events, companies and public administration were forced to change the way of communication with a customer/citizen. The article focuses on the area of new digital services created during the COVID–19 epidemic for the communication of citizens as well as legal entities with public administration bodies. The aim of the article is to evaluate the possibilities provided by public administration for communication with citizens and companies, as well as to outline the weaknesses from the point of view of public administration and citizens and possible recommendations for further development of these services.

Keywords: information security

JEL Classification: please select appropriate classification (predefined style “JEL”)

1. Introduction

SARS–CoV–2 (COVID–19) is a highly infectious disease that appeared in Asia in late 2019 and has spread worldwide. Each state reacted differently to the problem. Some states have imposed a "lockdown" on their territory – a regulation where people (apart from strategically important professions – such as firefighters or paramedics) had to stay only in their homes and could go outside for vital needs, such as foodstuffs. Other states have had their people "soaked" to create collective immunity.

As for the Czech Republic, on which this article is focused, it went its own way. In the spring, the quarantine was first ordered, when people were forced to work from home (home office), if their work allowed it. Many industries were closed, including school facilities that operated under distance learning. There were also restrictions on movement, especially in the number of people who could move outside and when it was necessary

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