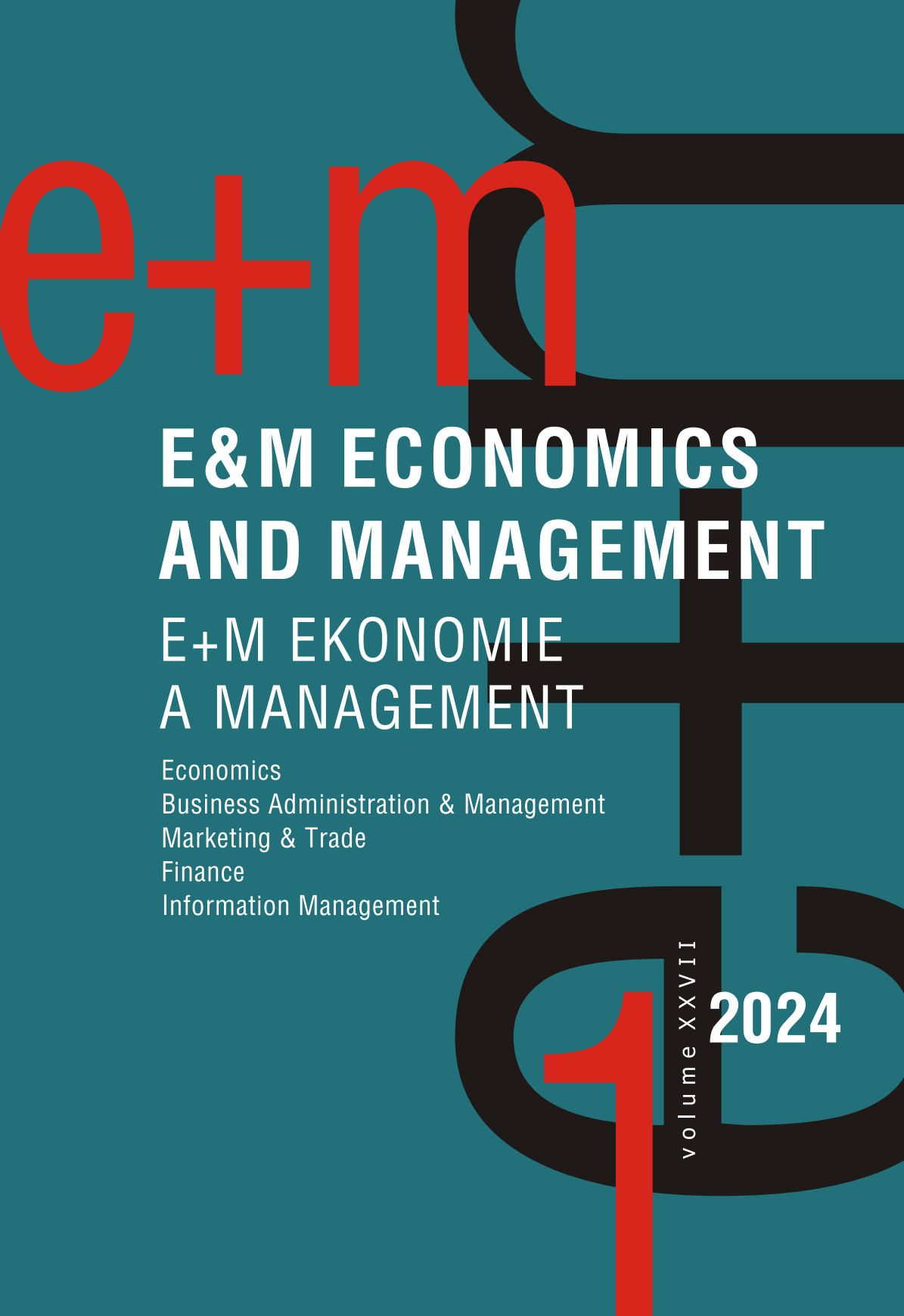

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Obituary of Professor Milan Zeleny

"Regardless of what you say, it only matters what you do. This helps everyone who wants to understand the world, adapt, find self-confidence, and carve out a new, unique path."

On Christmas Eve, when the entire Christian world commemorated the birth of the Savior, Milan Zeleny, a Czech-American economist, left us in the early morning hours at the age of 81, surrounded by his family in New Jersey.

Milan Zeleny, a respected member of the E&M Economics and Management Scientific Board, specializing in labour productivity, management theory, business economics, and multicriteria decision-making, was born in 1942 in Klucké Chvalovice near Čáslav. His father was Josef Zeleny, a Prague organizational consultant from the Czech Zeleny family (descendant of Václav Vladivoj Zeleny, a literary critic and a friend of Smetana and Němcová). His mother was Marie, nee. Barvínková, from a Czech Brethren family from the Orlické Mountains. After 1948, his father was transferred to the mines while his brother Jaroslav was transferred to the uranium mines in Jáchymov. This "mining" background enabled Milan to study at Sladkovský Gymnasium in Žižkov and subsequently at the University of Economics in the fields of labour economics, political economy, finance and quantitative methods. He was the best student, the so-called valedictorian of the class. He then joined Professor Ota Šik at the Institute of Economics of the Czechoslovak Academy of Sciences in the Economic and Mathematical Laboratory. In 1965, Professor Zeleny won an audition for the University of Rochester in South East England, but thanks to Professor Šik's intervention and the resolution of the Komárek-Kazan affair, he went to study in the USA in August 1967, where he sailed on the Queen Elisabeth.

He remained a convinced non-party member throughout his entire life. Professor Zeleny always considered autonomy and independence as inviolable attributes of an individual. Even before leaving for the USA, he had over 40 scientific publications in the field of managing complex projects, economics, and decision-making, a lot of them in English. In 1968, he was expelled from the Academy of Sciences, deprived of his job position and apartment, and urged to return immediately. He refused to comply, completed his studies in the USA, and obtained American citizenship. His publications were criticized for an "American stance," and in Czechoslovakia, they were completely banned until 1989. Unfortunately, the publishing opportunities in Czechoslovakia were decreasing, and citations of his professional works were actively restricted. From 1989 to 2000, he was considered a foreigner in the Czech Republic and had to report regularly to the immigration police. In exile, Milan Zeleny obtained the titles of Master of Science and Doctor of Philosophy at the University of Rochester. He served as a professor of business management at Columbia University for ten years and received a lifelong professorship at Fordham University in New York. His American professorship was not recognized in the Czech Republic. He also cooperated with Tomas Bata University in Zlín and at universities in China, Taiwan, India, Brazil, and other countries.

In the rankings of the most cited Czech economists, he consistently holds the top position. He also received several international awards, such as the Von Humboldt Stiftung, Rockefeller Foundation, Fulbright Foundation, and G. Cantor Award of the MCDM Society. He is the author of nearly 500 scientific publications and over 600 essays, short stories, popular articles, and newspaper articles. On the premises of his home university, Tomas Bata University in Zlín, Professor Milan Zeleny, along with his collaborators, established the ZET Foundation with the aim of promoting national entrepreneurship in terms of developing national, regional, and local

ownership, decision-making, autonomy, and self-sufficiency to enhance the competitiveness of Czech businesses, as well as those in the USA, China, and other transforming economies.

Honour to his memory.

Ass. Prof. Zuzana Tuckova
Tomas Bata Univerzity in Zlín
E&M Editorial Board member

The nexus of a regional competitiveness and economic resilience: The evidence-based on V4+4 NUTS 2 regions

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Abstract: *Economies have always been prone to economic downturns, industry shocks, currency crises, and the current COVID-19 epidemic crises, destabilising a region's economic growth trajectory and pattern. By re-establishing economic ties both inside and outside regions, regional economies that have been disturbed by a shock may transition to a new growth trajectory. We examined the idea of competitiveness and resilience in a regional development context to answer why one region is more susceptible to economic shock than others and the competitive advantages and disadvantages of V4+4 countries. This article highlights some of the core characteristics of regional competitiveness and resilience and gives a survey of the notion, main empirical results, and planning tasks concerning regional competitiveness and resilience. The idea of resilience is gaining greatness because of the COVID-19 crisis, and its importance is growing in research and economic policymaking. Ideas like "2020 made us stronger" and "resilience, tenacity, and the ability to bounce back" are obviously alluring during the current crisis. The COVID-19 problem, however, has decreased the main systems' shock resistance and caused failures to spread from one system to another. Thus, it is necessary to suggest a systems approach focused on resilience to have socio-economic systems ready for potential shocks. The paper's main topic is resilience-focused tactics, with a focus on the current European Union strategy. The European Union must strengthen its resilience considering the COVID-19 issue and the political agenda that is transition-driven in order to move forward or recover but emerge stronger. If policies are to be effective in the long run, an attitude responding to the systemic causes and impacts of big shocks is required.*

Keywords: *Economic shocks, regional development, V4+4 countries analysis, economic resilience, regional competitiveness index.*

JEL Classification: *C46, O18, O52, R10, R11.*

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Introduction

Any territory's geographical map can be used to spot an unbalanced population distribution quickly. Instead of the less populated surroundings, these maps frequently show minor, densely populated "nodal" points. Natural reasons can be used to explain why there is an uneven distribution of people and economic activity over space. Terrain configurations and climatic factors make some areas of the world

uninhabitable. On the other side, settlement expansion and development are facilitated by the fertile ground near water supplies. However, a significant portion of the pattern of the uneven spatial distribution of economic activity cannot be entirely attributable to geographical causes but rather to a variety of endogenous factors (De Bruyne, 2006). The attractiveness of a region for inflows of economic activity is determined by the socio-institutional framework. According to Danon (2014), the activity is unevenly dispersed throughout several territories because of several endogenous causes. Aspects of production that are adrift may migrate between sites because of these interregional variations. Territories might be seen as contending for the attraction and retention of economic activity in this environment if we suppose a finite set of factors of production with a marginal amount of mobility. The measure of success in this competition can be described as regional competitiveness according to Camagni (2002). In this context, a region characterised by the dominance of agglomerative forces over dispersive forces experiences a continuous inflow of mobile production inputs, indicating success. Conversely, an uncompetitive region faces the constant risk of losing footloose forces and experiencing decline. The emphasis on regions stems from the growing recognition that they are the prime spatial units where economies of scale and knowledge generation occur simultaneously (Huggins, 2003). This leads to the conclusion that competition takes place among regions or sub-national areas rather than countries. A region is a good option since it has a uniform institutional framework, a similar economic and social structure, and is generally homogeneous. At the same time, it often does not discard country rights.

Thus, the region has recently emerged as a complex and challenging subject for economic research. Many spatial topics, particularly territorial or regional ones, are increasingly challenging competitiveness as the new economic geography enters the mainstream. According to Krugman (2003), it is conceivable to talk of regional competitiveness as a region's ability to draw in and hold on to mobile factors of production, a topic that is becoming more and more significant in a global economy that is ever more integrated. Yet, this area of economic geography is still developing and lacks measurements that are generally recognised. Multiple studies demonstrate that regions vary in their ability to effectively address the challenges posed by evolving global competition, influenced by changes in the global environment. Regional competitiveness has been heavily researched over the past few decades. But they fall short of offering a thorough justification and a suitable, transportable remedy. To support competitiveness, particularly for nations and regions, it is vital to establish the framework conditions for the growth of the infrastructure, human capital, technology, and effective markets that can assist draw in talent and investment. Being competitive also involves having the necessary preconditions to endure unforeseen external shocks or the capacity of a regional economy to withstand, absorb, or recover from such a shock. It is important to keep in mind that resistance to an economic shock does not always mean that the economy is stable and doing well in the long run. As practitioners of economic development have worked to understand the elements that influence an area's capacity to resist and recover from economic shocks, resilience has become a growing subject of research. Regional economic resilience has become a crucial area of study due to factors such as globalisation, rapid technological advancement, severe recessions, and man-made calamities. Regional variations exist in how these exogenous shocks and recovery mechanisms affect the economy. One of the key disadvantages that limit a region's ability to absorb an external shock is a lack of economic diversification, confirming the close interrelation of the competitiveness and resilience ideas.

The article aims at revealing mechanisms of interplay between competitiveness and resilience across regions by identifying the dynamics of competitiveness and resilience. The comparative approach helps us better understand the nexus of competitiveness and resilience, and therefore, the article's reasoning may offer valuable insights for future regional policies. Results show the ability of a region to offer an attractive environment for firms and residents to live and work. The section of the article dealing with regional competitiveness is based on the methodological approach in the form of composite index, and benchmark of regional competitiveness scores to highlight the changes over time. The section of the article dealing with regional resilience is based on an assessment of the economic resilience

of regions based on employment and gross domestic product.

Why is it so crucial to measure regional resilience and competitiveness? Because you cannot improve something if you cannot measure it (Drucker, 2004). The regions will find it easier to identify potential weaknesses and the key elements causing these weaknesses and, conversely, the strengths with the aid of a quantitative competitiveness and resilience score. In turn, this will help the areas catch up with the process. To do this, the article has employed a mixed-methods approach that has combined quantitative data analysis with qualitative fieldwork. The article provides several associated conceptual questions that form the foundations for the work undertaken. Based on the evaluation of the relevant literature, the research hypotheses of the presented work were defined:

H1: A significant link between competitiveness and resilience exists in a regional context.

H2: The highest level of resilience characterises the most competitive regions.

Finally, it should be highlighted that evaluations have a strong quantitative component, and the concepts of the supplied issues are, in this sense, more statistical than analytical or methodical. Yet, background information also includes theoretical and philosophical elements. At the article's core is the application of selected quantitative methods to study geographical elements of competitiveness and resilience using data in detailed regional divisions.

The sections of the article are structured as follows. Section 1 provides a comprehensive survey of regional competitiveness and economic resilience and introduces the main aspects of theoretical and empirical issues. Section 2 introduces the methodology adopted to study regional competitiveness and economic resilience. Section 3 presents the empirical findings of the quantitative analysis of regional competitiveness and economic resilience. Section 4 helps to bring everything together and ensures a comparative study of both concepts, providing a concluding summary of the main findings. Finally, the conclusions put the topic into the context of COVID-19 reality and the reality of the Russian Federation invading Ukraine; both exogenous types of shocks are clearly and undoubtedly associated with the search for a strategy to be a more resilient economy based on competitive advantages, eventually searching for new competitive advantages.

1. Theoretical background

Economic downturns, sector shocks, and currency crises – all of which can disrupt the trajectory and pattern of regional economic growth – have long been a threat to economies. By reestablishing economic ties both within the region and with other regions, a regional economy that has been shaken by a shock may start on a new growth path. Regions are increasingly taking the lead in shaping the global economy. One of the most noticeable characteristics of regional economies is frequently the existence of clusters or geographic concentrations of related industries. The relocation of production operations to locations with better conditions undermines current economic fundamentals. The regionalisation of public policy also affects the emphasis on regions in the European Union (EU) in accordance with the subsidiarity concept because of a change in governing and the coordination of operations at the regional level. Governmental circles have been more interested in the regional underpinnings of national economies and in creating novel regionally-oriented policy interventions to help boost regional competitiveness and, subsequently the national economy. As a result, regions become more crucial to the economic growth of nations. We examined the idea of competitiveness and resilience in a regional development context to answer why some regions are more susceptible to economic shock than others, as well as the advantages and disadvantages of each region's competitive environment.

1.1 Concept of competitiveness

Although the idea of competitiveness is one of the most common in economics, it is not well defined. Hence, there is no accepted definition of it. The level at which the concept of competitiveness is described is crucial; typically, the micro and macro levels are strictly interrelated. According to the World Economic Forum (WEF), one of the most important definitions of competitiveness is the collection of institutions, policies, and variables that affect productivity (Schwab & Porter, 2007). The WEF defines competitiveness at macro (country) and micro (company) levels. The relationship between the two levels is clear: while a stable macroeconomic environment promotes opportunities

for wealth creation, it does not produce wealth independently. The ability to produce goods and services while utilising capital, human capital, and natural resources is what generates prosperity. Productivity, on the other hand, is defined by the microeconomic capacity of the economy, which is basically decided by the efficacy and quality of the firms (Martin et al., 2006). The implicit comparison between corporations and governments has drawn a lot of ire because a country cannot go out of business, and rivalry between nations can be beneficial to both. Many scholars, including Krugman (2003), acknowledge that productivity – the value of goods and services produced by a country per unit of human, capital, and natural resources – is the best way to define competitiveness. A nation's ability to support high wages, a robust currency, compelling returns on investment, and a high standard of living is due to its productivity (Porter, 2003). Today, one of the most closely watched aspects of national economies is their level of competitiveness, which is increasingly being used to measure their prosperity, welfare, and living standards. Although it has quickly reached the regional level, the idea of competition is also debatable. Regional competitiveness cannot be classified as a macro or a micro idea. A region is more than just a group of companies or a smaller version of a nation (Gardiner et al., 2004). According to Meyer-Stamer (2008), a territory's competitiveness can be assessed by looking at its ability to generate significant and rising revenue streams and raise the standard of living for its citizens.

The academic interest in the issue of regional competitiveness has grown more and more, summing up many publications (Grassia et al., 2022). The multifaceted nature of regional competitiveness makes it challenging to provide a definition as well as a context for measuring and subsequently evaluating. The debate concerning different dimensions and topics or themes related to competitiveness, or the "new competition," influences the diverse strategies and actions that can be carried out for improving the socio-economic conditions of a given areas, especially regions (generally, territorial competitiveness of countries, regions or cities). The formulation of regional competitiveness thus affects the current and relatively new debate considering all possible contexts affecting regions and their performance, e.g., Garcia-Alvarez-Coque et al. (2021) differ in three conceptions of regional competitiveness (regions as sites of specialisation, regions as a source of increasing returns, regions as hubs of knowledge and economic trade. The heterogeneity of regional competitiveness definition is a widely discussed theme and can be triggered by several factors. This source of differentiation, regarded as the intersection of socio-economic and cultural components, can be the key to success for many regions (Dagiliene et al., 2020; Lavrinenko et al., 2019; Pietrzak et al., 2017; Sagiyeva et al., 2018; Zeibote et al., 2019). In contrast to the WEF definition, which strongly emphasises productivity, this definition is exclusively centred on the advantages for residents. Therefore, regional competitiveness can be characterised as the capacity to provide a desirable and sustainable environment for enterprises and people to live and work. Such a description is offered by Dijkstra et al. (2011) and includes the perspectives of both firms and people. According to the Sixth Progress Report on Economic and Social Cohesion (European Commission, 2009), despite the likelihood of significant variance in the competitiveness of the firms located within the region, it is challenging to incorporate into a regional competitiveness index (RCI) the assumption that every region has standard elements that influence and drive the competitiveness of all the enterprises placed there. The workforce's skills, the efficiency and justice of the institutions, and the physical and social infrastructure should all be included in this list. The EU promotes competitiveness by implementing policies that improve the climate for doing business, foster innovation, modernise the industrial base, and provide varied levels of sectoral aid and support for structural change through the coordination of economic policy. Such assistance is provided through several programs run by the European Commission (EC) and the European Structural and Investment Funds (ESIF).

1.2 Concept of resilience

The economic resilience of regions has been defined by many authors (e.g., Navarrete, 2011; Pelling & Manuel-Navarrete, 2011). Broadly defined regional resilience is mentioned in the literature describing the effects of natural or anthropogenic catastrophes (Holling, 2002; Pelling & Manuel-Navarrete, 2011; Sutton et al., 2023). The origin of the concept of regional

resilience is stamped mainly from environmental studies that studied the adaptation of ecosystems (Hill, 2012). The concept is used by a range of scientists, from economic geographers to regional analysts and economists. We could mainly mention Pendall et al. (2010) and Foster (2007). Among the Czech scientists, we can mention Kraft et al. (2011) and Koutský et al. (2012). Martin and Sunley (2015) point out that the existence of many different definitions is confusing but that it is caused by adopting the idea of resilience from various scientific disciplines. Above all possible definitions, we must stress the definition of so-called engineering resilience. This approach describes resilience as the resistance of the economic system to disturbance, and the main character is the speed of recovery of the economic system.

The engineering resilience approach means that the less the region is affected by disturbance, the sooner it returns to its steady state and the more resilient the region can be. This interpretation assumes that the economic system has only one steady state or equilibrium, which some scientists see as non-realistic; the approach of ecological understanding instead of seeing the possibility of many steady-states or equilibrium. These steady states can be reached after external shocks. Disturbances and shocks can move the system from one equilibrium to another (Fingleton et al., 2012). According to the ecological approach, the resilient economic system adapts by either resuming or improving its long-run equilibrium growth path (Gong et al., 2020; Simmie & Martin, 2010). That is an attribute of complex adaptive systems (Balland et al., 2015; Simmie & Martin, 2010). According to the ecological approach, resilience is an evolutionary process of continual adjustments. Many other definitions claim that resilience means the capacity of the system to resist, withstand or quickly recover from negative exogenous shocks and disturbances and to renew, adjust or re-orientate from these shocks (Bigos et al., 2013). From a methodological point of view, we must conclude that many studies focusing on economic crisis use the first (engineering) approach due to its simplicity and methodological clarity. The same approach will also be used in this study. Above all, it is important to add that the shock response mechanism depends on regional actors and forms not only region-specific but also sector-specific patterns of response and adaptation (Martin & Sunley, 2015; Wang & Ge, 2023). Not only internal actors but also exogenous economic actors and cross-regional relationships strongly influence regional resilience. The importance is seen in international moves of interacting agents that exploit flexible spatial configurations and power relations (Hou et al., 2023; Pike et al., 2010).

2. Approaches and methods to measuring competitiveness and resilience

The complexity of defining competitiveness and resilience leads to difficulties in their measurement. Evaluation is no less complicated than the definition and understanding of both concepts. Creating an evaluation system is complicated by the heterogeneity of territories and its approach to the original idea of competitiveness and resilience. There is a space for alternative techniques because of the lack of a mainstream view of the evaluation of concepts. There are several approaches for analysing regional economies, and most of them have drawbacks, particularly when it comes to identifying appropriate indicators and weighting schemes (if needed and required). Currently, quantitative and qualitative development at the regional level increases socio-economic attraction and creates new opportunities for overcoming disparities, increasing competitiveness and boosting the resilience of regions.

2.1 Measuring competitiveness

Considering the different positions that emerged from the literature review, it is logical that this also evokes developments in approaches to measuring competitiveness. Afterwards, “competitiveness” is a relative term that requires comparison with others; areas are compelled to continuously monitor and periodically benchmark what the competition is doing to determine where the best practice or best offer is located. The goal of competitiveness has, therefore, taken on major relevance for policymakers. Interest in assessing regional competitive performance and developing measures to promote and enhance competitiveness has increased within government circles. In fact, the European Commission has enthusiastically promoted regional competitiveness as a policy objective. It has gained notoriety in the United Kingdom, where the national government’s policy pronouncements now emphasise pursuing regional competitiveness. Due to this, there

is now a lot of interest in constructing composite indices (CIs), enabling the comparison of regions based on individual scores and ranks (Berger, 2011). CIs can be beneficial for illustrating regional differences in particular economic situations. More and more scholars have studied the benchmarking of locations over the past few years. Numerous reputable studies that use a standard methodology measure competitiveness at the national level. Global competitiveness index (GCI), included in the World Economic Forum's (WEF) Global Competitiveness Report (GCR), and the Institute for Management Development's (IMD) World Competitiveness Yearbook (WCY) are by far the most significant and well-known indices at the national level. The GCI is the most often used index and includes many competitiveness-related factors. More recently, particularly in the EU, attempts have been made to expand the national analysis at the regional level.

The Atlas of Regional Competitiveness (Eurochambers, 2007), which reflects the significance of the areas at the EU NUTS 2 level being recognised internationally, provides a more complete geographical definition of competitiveness. The variables are not, however, effectively combined by the approach into a composite index. Some European nations have worked hard to develop national indicators of regional competitiveness, such as Croatia (UNDP, 2008), the UK (Huggins & Izushi, 2008), Finland (Huovari et al., 2001), Lithuania (Snieška & Bruneckienė, 2009), in the Visegrad Four Countries or their NUTS 2 regions (Melecký & Skokan, 2011) and the Czech Republic (Žižka, 2013). The most accessible and also the most popular group of approaches today are composite indices. We can mention the works of D'Urso et al. (2019) or González Catalán (2021). Even though regions receive mixed reviews compared to other regions in various competitiveness rankings studies, a simple and feasible conclusion can be drawn from these results and can be considered as the relevant background for sophisticated benchmarking and comparison (Rodríguez-Díaz et al., 2021). The literature's most widely acclaimed index is seemingly the regional competitiveness index constructed for the EU by Annoni and Kozovska (2010) and subsequently enhanced, enlarged and updated by Annoni and Dijkstra (2013), Annoni et al. (2017), Annoni and Dijkstra (2019) and Dijkstra et al. (2023). RCI includes regions at the EU NUTS 2 level. These studies coincide with the EC reports on economic, social and territorial cohesion. RCI's extensive territorial coverage and methodological rigour make it an excellent resource for endorsing the European Commission's policies.

2.2 Measuring resilience

Measuring regional employment, regional output, and other factors (such as regional wages, regional labor productivity, or regional investments) is the suggested method for evaluating regional economic resilience (ESPON, 2014). Regional products or employment at the regional level are the most common basis for quantifying regional resilience. Due to the problematic determination of regional products, regional employment is often analysed (Simmie & Martin, 2010). However, both indicators have their advantages and disadvantages. A common drawback of both indicators is the inability to shield the impact of commuting.

The literature has used a variety of techniques to gauge economic resilience (Martin & Sunley, 2015; Modica & Reggiani, 2015). While some authors (Fingleton et al., 2012; Lagravinese, 2015) advocate the use of univariate indicators based on GDP per capita or employment rates to measure the concept of resilience, another strategy has been the development of composite indexes based on a variety of variables that may adversely affect the degree of economic vulnerability (Briguglio, 2014; Melecký & Staníčková, 2015; Modica & Reggiani, 2015; Svoboda & Cichá, 2015). There are many different approaches to calculating indices representing the region's sensitivity to the crisis in the literature. This article used an index based on GDP p.c. and employment calculated like % change between given years. Another possible approach to measuring a crisis's impact is comparing growth rates before and after the crisis. For this purpose, we employed beta coefficients of regional time series representing a growth rate of GDP p.c. and employment, respectively. The advantage of the beta coefficient compared to the geometrically calculated average growth rate stems from its robustness to possible extremal values at the time series' beginning and end. Indexes are based on NUTS 2 regional GDP p.c. and employment retrieved from Eurostat (2022). The first mentioned index was calculated for each region based on GDP p.c., resp. number

of employed persons according to ESPON (2014), Equation (1):

$$index_i = \left(\frac{y_{i,t+n}}{y_{i,t}}\right) \quad (1)$$

where: *index* – % change of GDP p.c. (thousands of employed persons); *y* – regional GDP p.c. (thousands of employed persons); *t* – number of basic year (year 2008 can be considered as the last year before the crisis); *n* – the length of the examined period in years; *i* – the number of region.

To evaluate the impact of the crisis, index was calculated for GDP p.c. between years 2008 and 2009 and for employment between years 2008 and 2011. The period for employment is intentionally more extended than in the case of GDP p.c. because of the lag in labor market development. The second index (regional category) was calculated for each region via two beta coefficients – one before and one after the crisis (Wooldridge, 2016; Equation (2)):

$$\beta = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sum_{i=1}^{n}(X_i - \bar{X})^2} \quad (2)$$

where: β – beta coefficient of regression equation calculated for each region within two six years-long periods; β_1 is calculated before the crisis (2001–2006) and β_2 is calculated after the crisis (2010–2015), years 2007–2009 are intentionally omitted due to abnormal GDP/employment growth/decline rate; $\bar{X}$ and $\bar{Y}$ – the average of the X_i and Y_i, respectively; X_i stands for time and Y_i for regional values of GDP p.c./thousands of employed persons; *n* – the number of examined values in each time series.

Based on beta coefficients, regions were classified according to rules in Tab. 1 into four categories:

Category 1: Regions with relatively higher growth rates in both periods.

Category 2: Regions with relatively higher growth rate only in 2010–2015 (after crisis).

Category 3: Regions with relatively higher growth rate only in 2001–2006 (before crisis).

Category 4: Regions with relatively lower growth rates in both periods.

Tab. 1: Regional categories according to resilience point of view

Category	Rule	Description
1	β_1 > median of β_1 and β_2 > median of β_2	The pre-crisis growth rate and post-crisis growth rate above the median
2	$\beta_1 \leq$ median of β_1 and β_2 > median of β_2	The pre-crisis growth rate below the median (or equal to median rate) and post-crisis growth rate above the median
3	β_1 > median of β_1 and $\beta_2 \leq$ median of β_2	The pre-crisis growth rate above the median and post-crisis growth rate below the median (or equal to median rate)
4	$\beta_1 \leq$ median of β_1 and $\beta_2 \leq$ median of β_2	Pre-crisis and post-crisis growth rates below the median (or equal to median rate)

Source: own

3. Results of competitiveness and resilience

The Visegrad Group (V4) is the focus of the empirical analysis's geographic coverage, reflecting the efforts of the Central European countries to cooperate in several areas of shared interest as part of the integration of all of Europe. The nations of Czechia (CZ), Hungary (HU), Poland (PL), and Slovakia (SK) have long been a part of a unified civilisation that shared common cultural and intellectual values as well as roots in various religious traditions. These nations want to protect and further build this civilisation. The participating countries perceive their cooperation as a challenge and its success as the best proof of their ability to integrate into such structures as the EU (Visegrad Group, 2019). For this purpose, V4 cooperates with other regional bodies, as well as with single countries in the region and beyond on an ad-hoc

or regular basis, which made the V4+4 format (V4 + Bulgaria (BG), Croatia (HR), Romania (RO) and Slovenia (SI)). All these countries belong to the group of so-called "new" EU Member States or into the EU13 group, i.e., countries that joined the EU in 2004 (Czechia, Hungary, Poland, Slovakia and Slovenia), 2007 (Bulgaria and Romania), and 2013 (Croatia). These are countries that are net recipients of the EU budget and benefit significantly from ESIF for the overall development of their territory. Due to the EU Cohesion Policy and the setting of the funds' distribution, development is essential. Evaluating competitiveness and resilience is crucial for policymakers to identify regional strengths and weaknesses and to develop targeted regional development strategies that prioritise necessary investments in areas requiring improvement. The investigated territory analysis is based on the classification of EU NUTS (Nomenclature of Territorial Units for Statistics). The empirical research primarily concentrates on NUTS 2 regions, which are administrative or statistical regions that do not consider functional economic connections. Geographical coverage of empirical analysis consists of 53 NUTS 2 regions, i.e., 8 NUTS 2 CZ, 7 NUTS 2 HU, 16 NUTS 2 PL, 4 NUTS 2 SK, 6 NUTS 2 BG, 2 NUTS 2 CR, 8 NUTS 2 RO, 2 NUTS 2 SI.

3.1 Results of competitiveness

The RCI offers a distinctive policy instrument to monitor and evaluate the competitiveness of every NUTS 2 region within the European Union. RCI offers the first broad picture of the situation of regions, recognising the cross-regional comparison among the EU Member States. According to authors (Annoni & Dijkstra, 2013, 2019; Annoni et al., 2017; Annoni & Kozovska, 2010), RCI enables the expansion of conventional competitiveness research to include viewpoints from both firms and residents, taking into account both economic performance and individual well-being. These factors have been chosen following the EC's definition of competitiveness for RCI, a region's capacity to provide a desirable and sustainable environment for businesses and citizens to live and work in.

The main goal of RCI calculation has been to keep it straightforward, understandable to non-statisticians, and consistent (Annoni & Kozovska, 2010). Consequently, the final RCI is constructed through a sequential aggregation process. Initially, the scores for each dimension of the RCI or within each pillar are determined by taking a simple arithmetic average of the normalised and converted indicators. In the subsequent stage, the arithmetic means of the dimension scores are calculated to obtain the scores for the three classes of competitiveness dimensions, namely basic, efficiency, and innovation. Standardised (*z*-scores) indicator values were utilised to create RCI sub-scores for each pillar. The sub-indices (scores) at the pillar class level are then computed by averaging the relevant sub-scores. In order to construct a sub-index for each of the three pillar classes (basic, efficiency, and innovation), the pillar scores for each class group are simply averaged. For each region *i,* the sub-scores allotted with the dimension classes are:

$$RCI_{basic}(i) = \frac{1}{5}\sum_{j=1}^{5} \text{score}(i,j) \tag{3}$$

Score (*i, j*) is the score allotted to region *i* for dimension *j; RCI_{basic}* presents sub-index of RCI for *i*-th region; *i* is V4+4 NUTS 2 region; *i* ∈ {1 = BG31, … , 53 = SK04}; *j* is appropriate competitiveness pillar for the sub-dimension index's RCI_{basic}; *j* ∈ {1 = institutions, 2 = macroeconomic stability, 3 = infrastructure, 4 = health, 5 = quality of primary and secondary education}.

$$RCI_{efficiency}(i) = \frac{1}{3}\sum_{j=6}^{8} \text{score}(i,j) \tag{4}$$

Score (*i, j*) is the score alloted to region *i* for dimension *j; $RCI_{efficiency}$* presents sub-index of RCI for *i*-th region; *i* is V4+4 NUTS 2 region; *i* ∈ {1 = BG31, … , 53 = SK04}; *j* is competitiveness pillar important to sub-index dimension $RCI_{efficiency}$; *j* ∈ {6 = higher education and training and lifelong learning, 7 = labour market efficiency, 8 = market size}.

$$RCI_{innovation}(i) = \frac{1}{3}\sum_{j=9}^{11} \text{score}(i,j) \tag{5}$$

Score (*i, j*) is the score alloted to region *i* for dimension *j*; $RCI_{innovation}$ presents sub-index of RCI for *i*-th region; *i* is V4+4 NUTS 2 region; *i* ∈ {1 = BG31, … , 53 = SK04}; *j* is pillar of

competitiveness compatible with dimension of sub-index $RCI_{innovation}$; $j \in \{9 = \text{technological readiness}, 10 = \text{business sophistication}, 11 = \text{innovation}\}$.

In the final step, RCI score is determined as a weighted average of three sub-scores:

$$RCI(i) = w_{basic} RCI_{basic}(i) + w_{efficiency} RCI_{efficiency}(i) + w_{innovation} RCI_{innovation}(i) \quad (6)$$

$$w_{basic} + w_{efficiency} + w_{innovation} = 1 \quad (7)$$

$$w \in \langle 0,1 \rangle \quad (8)$$

where: $RCI_{(i)}$ gives a weighted composite index RCI for *i*-th region; *w* is normalised weight of *i*-th region for *j*-th competitiveness pillar reflecting the pertinent sub-index.

The three sub-indices are combined into the final RCI score using a set of weights determined by the region's level of development. RCI adopts the WEF methodology for final aggregation, wherein GCI takes a country's stage of development (SoD) into account and gives various weighting schemes to different pillars (Schwab & Porter, 2007). A similar strategy is used for RCI since some variation in the EU NUTS 2 regions' developmental stages is anticipated. The set of weights used to combine the sub-indices is determined by the regions' GDP-based medium, intermediate, and high stages of development, as well as two transitional phases. For detailed information about SoD, see Annoni and Kozovska (2010), Annoni and Dijkstra (2013), Annoni et al. (2017), and Annoni and Dijkstra (2019).

A region's socio-economic situation changes as it develops, and other factors start to weigh more heavily on the level of regional competitiveness. Because of this, the greatest method to help less developed regions catch up is different from the best way to make more developed regions more competitive.

RCI accepts both favourable and unfavourable scores. A region is competitive when it has a positive score, whereas a region is not competitive when it receives a negative value. There is an expected level of similarity across the V4+4 countries, but the RCI results highlight significant variances in the level of economic development among regions within and between nations. The RCI exhibits a polycentric structure in most of the examined countries, characterised by the presence of significant capital cities and metropolitan areas. Like competitive regions surround certain capital areas, less competitive regions cover many capital regions. Significant differences exist between and within nations in the spatial distribution of competitiveness. Results from RCI editions reveal a polycentric trend, with extensive metropolitan areas and capital regions ranking the highest on the index. Competitiveness has usually stayed steady when comparing RCI versions. High within-country variances were frequently seen as a result of the capital region performing much better. Most of the top regions in every RCI edition are home to capital cities or sizable metropolises, contributing to the region's increased competitiveness. These regions are mainly in the Czech, Slovak, and Slovenian countries. At the other end of the spectrum, especially in Bulgaria and Romania, we discover several places that are regrettably consistently the lowest achievers. When comparing the country ratings, i.e., when calculating the national averages of RCI values, the resulting ranking of the countries is sequential, i.e., from Slovenia, Czechia, Slovakia, Poland, Croatia and Hungary to Romania and Bulgaria.

Fig. 1 shows cartograms of RCI results in reference periods 2010, 2013, 2016 and 2019 and changes across editions. For the geographical distribution of RCI scores, as a rule, the positive orientation of the index score is relevant. The higher the score, the higher (better) the level of competitiveness, and vice versa. The results of RCI are highlighted by the traffic light method. The range of colours of this method changes from dark shadows of red to dark shades of green. Regions with higher RCI scores have a better level of competitiveness and are highlighted by the dark green – the higher the score, the darker the shades of green. The overall pattern is not so different from the editions.

3.2 Results of resilience

The results of the economic resilience analysis are presented by the indicators derived from regional GDP p.c. and regional employment indexes (see cartograms in two columns of Fig. 2 – Part 1). The top cartogram in the first column shows the regional GDP p.c. change indicator during the recession (percentage of GDP p.c. difference between 2008 and

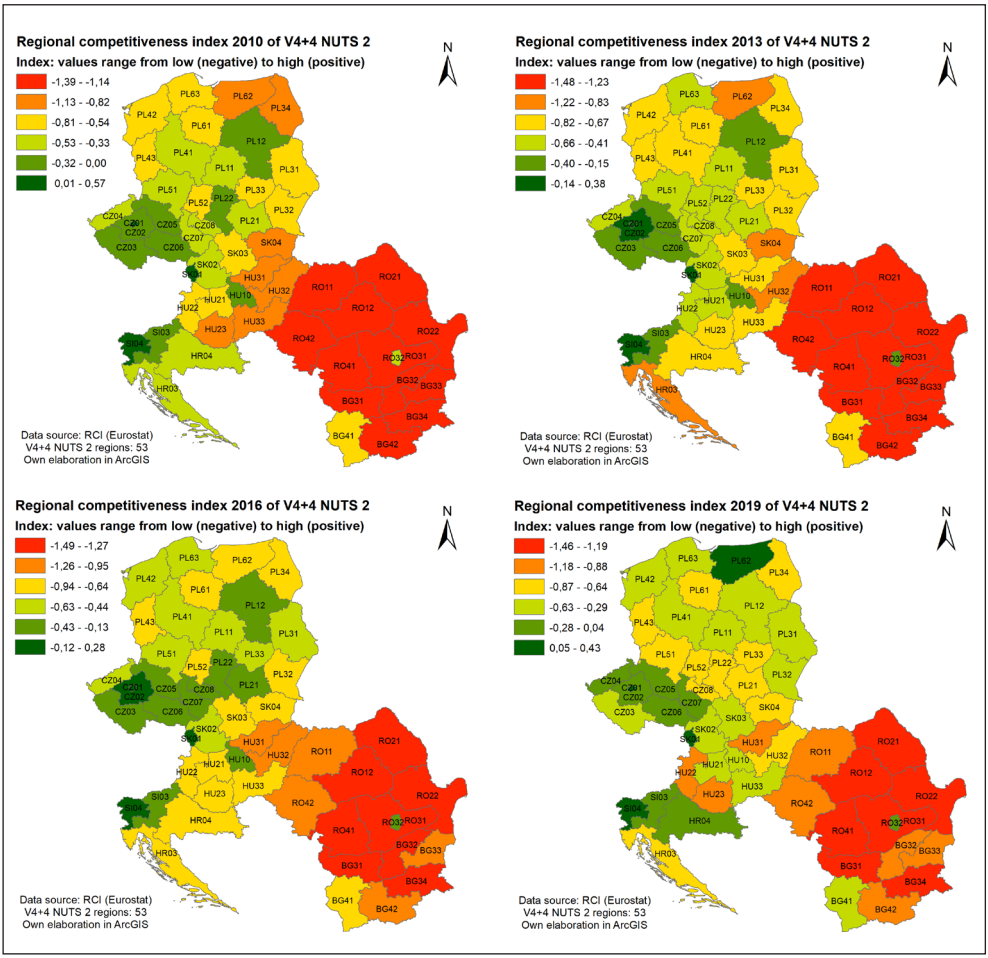

Fig. 1: RCI results

Source: own (in ArcGIS 10.5.1 (2022))

2009). Based on these results, it can be concluded that most of the V4+4 regions recorded declines in GDP p.c. The main exceptions were some of the Polish regions. The bottom cartogram in the first column (Fig. 2 – Part 1) shows the regional change in employment during the recession. The cartogram describes the percentage change in regional employment between 2008 and 2009. The situation here is very similar to the previous cartogram. Most of the V4+4 regions recorded a decline in employment. The exceptions included twelve regions of Poland, two regions of Czechia (CZ01, CZ02), one in Hungary (HU23), and four regions in Romania. The above cartograms can be compared to the next cartograms – the second column (Fig. 2 – Part 1) and first column (Fig. 2 – Part 2), i.e., four cartograms: changes in GDP p.c. and employment for 2008–2016, 2008–2019 resp. In the case of percentage changes in GDP p.c., the results comply with similar studies focusing on regional convergences (regions with a relatively lower level of GDP p.c., e.g., regions of Romania achieve high growth rates and vice versa). The second column (Fig. 2 – Part 2) contains two cartograms

showing the regions belonging to the specified classes. These two cartograms show the economic crisis's impacts on GDP p.c. growth rate (upper cartogram), respectively, in terms of employment growth rate (lower cartogram). Categorial values 1 or 2 for GDP post-crisis growth rate above the median are represented mainly by the Czech and Polish regions. Categorial values three and four prevail in regions from Slovenia, Romania, and Bulgaria. In the case of Hungary, all categories are presented at approximately the same frequency. From the point of employment rate view (lower cartogram in the fourth column), the categorial value one or two is represented mainly within the regions of Hungary, Slovakia, and Czechia. Categorial value three or four is presented in the case of Polish, Romanian, Bulgarian, and Croatian regions. Cartograms show that, as in the case of competitiveness analysis, resilience results show a level of heterogeneity over space (considerable differences in the strength of resilience of regional economies across and within countries). As in the case of RCI, a polycentric pattern with high economic resilience in the capital and metropolitan regions is shown

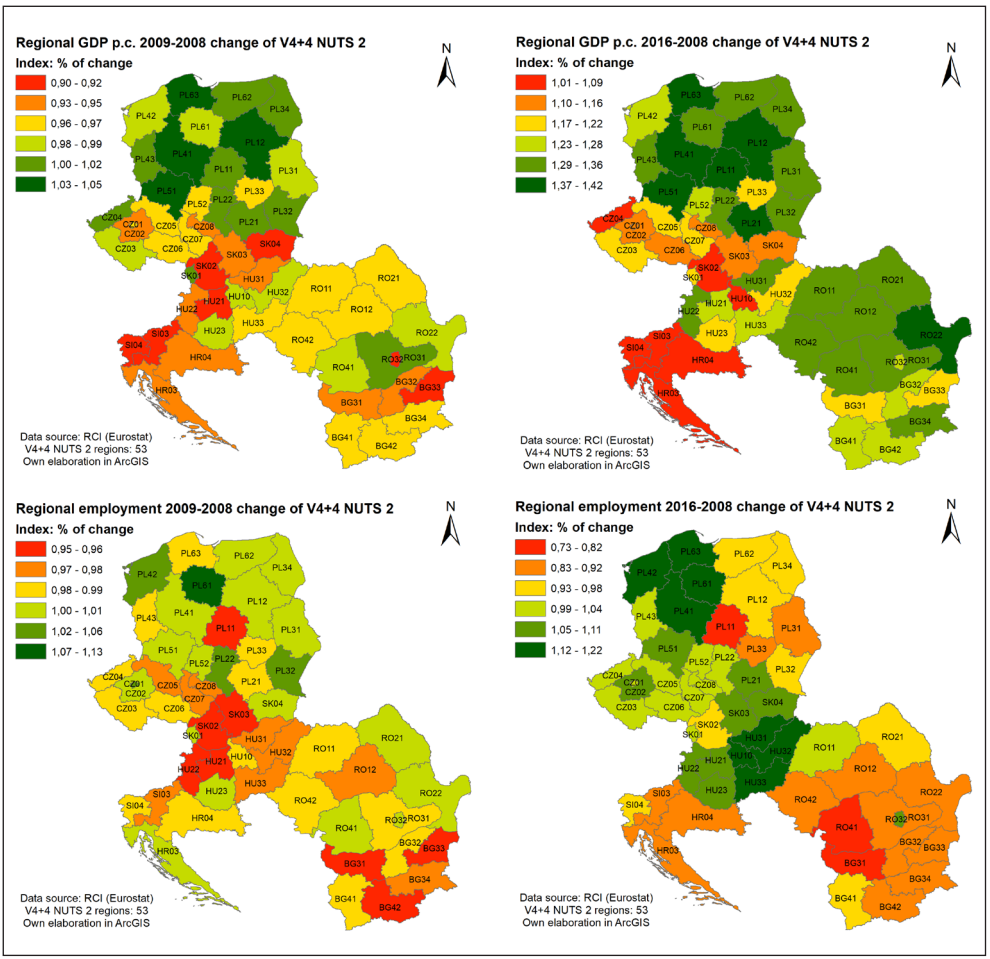

Fig. 2: **Resilience results – Part 1**

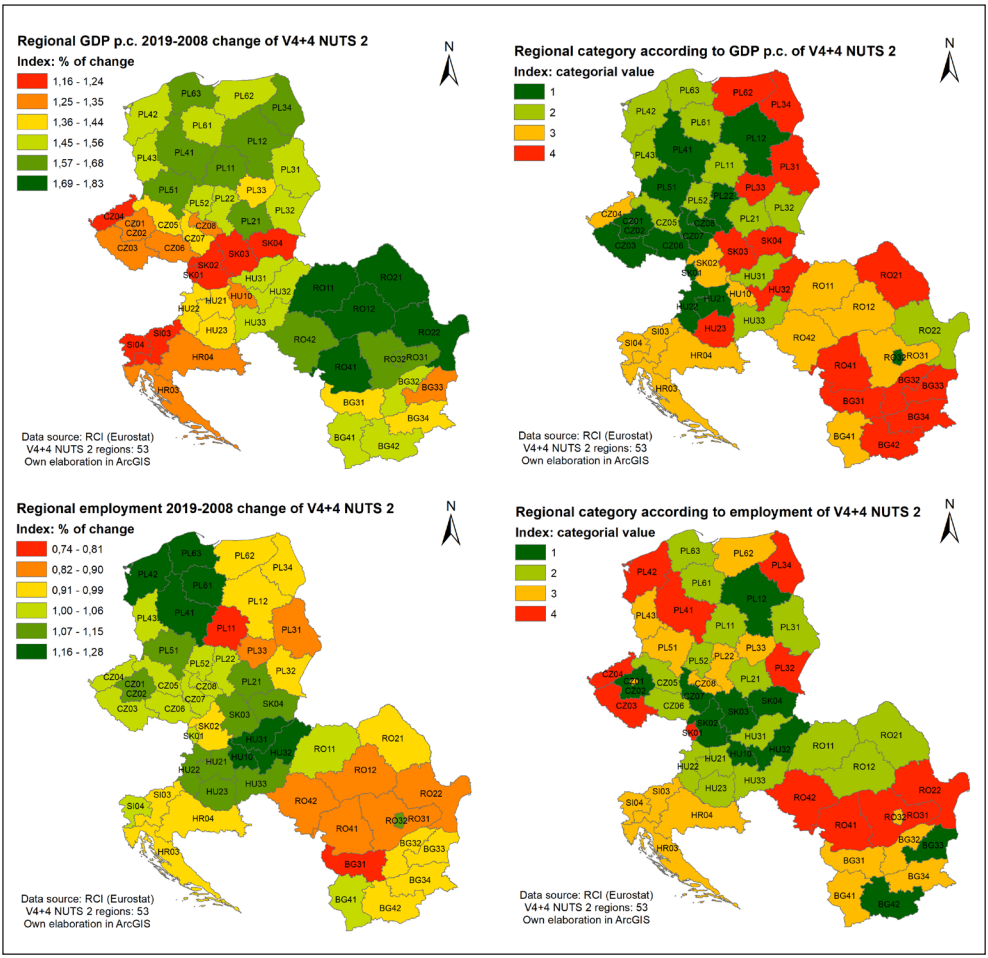

Fig. 2: **Resilience results – Part 2**

Source: own

in most countries under review. In addition, it should be noted that GDP p.c. resistance patterns show significant regional differences compared to employment resistance.

4. Comparison of empirical results of competitiveness and resilience

The V4+4 NUTS 2 regions' research on crisis resilience, particularly in relation to competitiveness, is managed within a theoretical and empirical scheme with the goals of identifying the effects of economic crises on regional economies, analysing structural and functional determinants in regions, attempting to explain why some regions are more resilient than others, and identifying policies that support economic resilience. The purpose is thus to develop a measure of resilience to crisis, one that may be applied to regional data and compared with the level of competitiveness of the same sample of evaluated regions. Generally, such a measure can take either a positive or negative score on competitiveness and resilience issues. A positive score confirms resilience to crisis and a higher level of competitiveness, whereas a negative one confirms the absence

of resilience and a lower level of competitiveness. Research hypotheses were tested in two versions corresponding to two forms of resilience assessment (the first included the relationship of competitiveness and GDP p.c., and the second included competitiveness and employment). For the GDP p.c. related resilience indicator, the years 2008 and 2009 were chosen for the indicator's calculation. 2008 can be considered a year not yet affected by the economic crisis. The year 2009 corresponds to the year when a significant product decrease occurred in many EU regions. In the case of the employment-related resilience indicator, the years 2008 and 2011 were chosen for the indicator's calculation (the year 2011 corresponds to the most frequent occurrence of the bottom of the business cycle in several European regions). The correlation analysis showed that the first correlation pair (GDP p.c. related resilience indicator vs average regional RCI score from 2010, 2013, 2016, and 2019) is not statistically significantly correlated (alpha = 0.01; R = 0.12). The second correlation pair (employment-related resilience indicator vs average regional RCI score) showed a statistically significant positive correlation at the significance level of alpha 0.01 (R = 0.59). A statistically significant negative correlation was also found between the regional RCI scores in 2010 and the regional categorical value by regional GDP p.c. growth (alpha = 0.01; R = −0.58). The results mentioned above can be considered as confirmation of the first hypothesis under investigation. Fig. 3 shows the relationship between the employment-related resilience indicator and the average regional RCI values.

A comparison of average RCI scores and employment change between 2011 and 2008 (Fig. 2) shows a statistically significant regression relationship (R^2 = 0.29; alfa = 0.01) between the short-term adaptation to the negative economic shock and the long-term adaptation represented by the RCI indicator. At first glance, at the same time, there are a few regions that can be considered outlier values (e.g., the capital regions SK01 and CZ01). RCI score above the median level (−0.618) was most often achieved by regions of Czechia and regions of Poland – specifically, this threshold was reached by all NUTS 2 regions of Czechia,

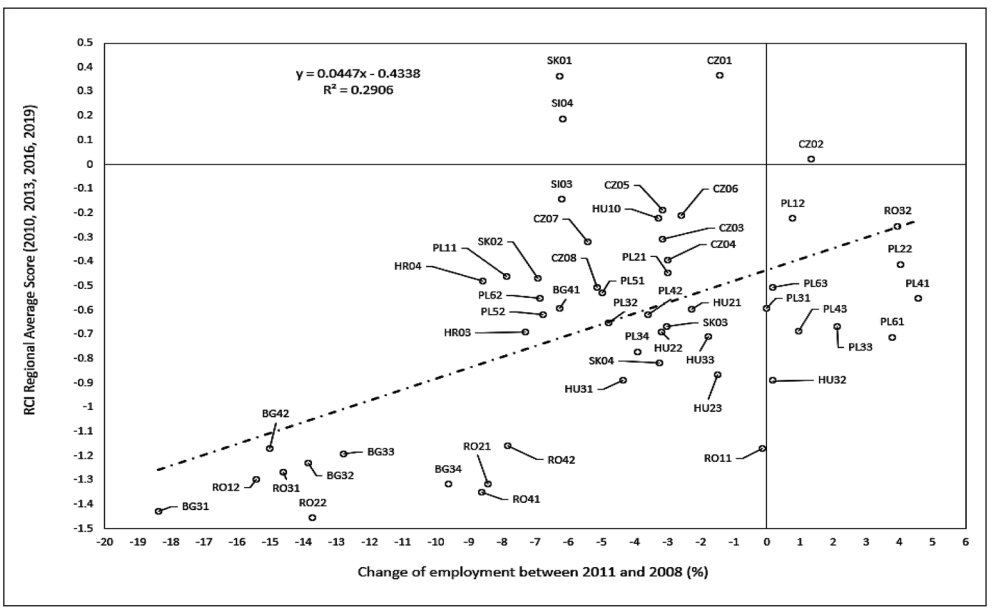

Fig. 3: Relationship between employment-related resilience and competitiveness

Source: own (based on RCI 2010, 2013, 2016, 2019; Eurostat (2022))

ten regions of Poland, two regions of Hungary (HU10, HU21), two regions of Slovakia (SK01, SK02) and Slovenia (SI03, SI0), one region of Croatia (HR04), one region of Romania (RO32) and one region of Bulgaria (BG41). The CZ regions (except CZ07 and CZ08), HU regions (except HU31), ten Polish regions, two Slovak regions (SK03, SK04), and two Romanian regions (RO11, RO32) recorded employment changes above the median level (−3.91%) within the examined period. Fig. 2 shows the central cluster of regions (all regions of Czechia, Poland, Slovakia, Hungary, and Croatia constitute the leading group). On the contrary, the second cluster of regions – in the lower left part of Fig. 2 – consists of most regions of Romania and Bulgaria.

Tab. 2 shows the results of comparing regional competitiveness and resilience for 53 regions. The first category comprises 15 regions with average RCI scores above the median and, simultaneously, with the percentage change in employment (Em) between 2011 and 2008 above the median. This category consists of very resilient and very competitive regions. 80% of all regions in this category are from Czechia and Poland. The second category consists of 11 regions with average RCI scores above the median and simultaneously with employment percentage change below (or equal) to the index's median. These regions are showing relatively high competitiveness but less resilience in employment. 73% of these regions in the examined sample are from Hungary and Poland. The third category consists of 11 regions with RCI below (or equal) to the median and simultaneously with an employment rate more significant than the median. These are regions that have shown relatively high resilience but lower competitiveness. Most of these regions are Polish, and more than half consist of Slovak, Czech and Slovenian regions. The last (fourth) category consists of 16 regions with average RCI scores and employment rates below (or equal to) the median of the given index. These regions have shown relatively low competitiveness and relatively low resilience in employment. 38% of these regions were regions from Romania, and more than a quarter were regions from Bulgaria. The results mentioned above can be considered as confirmation of the second hypothesis under investigation.

A thorough understanding of geographical parallels and differences, as well as an understanding of the types of local and regional

Tab. 2: Comparing regional competitiveness and regional resilience

Country	Category				Total
	1	2	3	4	
	RCI > median and Em > median	RCI > median and Em ≤ median	RCI ≤ median and Em > median	RCI ≤ median and Em ≤ median	
BG	–	–	1	5	**6**
CZ	6	–	2	–	**8**
HR	–	–	1	1	**2**
HU	2	4	–	1	**7**
PL	6	4	3	3	**16**
RO	1	1	–	6	**8**
SI	–	–	2	–	**2**
SK	–	2	2	–	**4**
Total	**15**	**11**	**11**	**16**	**53**

Note: RCI – regional competitiveness index; Em – percentage change in employment between 2011 and 2008; BG – Bulgaria, CZ – Czechia, HR – Croatia, HU – Hungary, PL – Poland, RO – Romania, SI – Slovenia, SK – Slovakia.

Source: own (based on RCI 2010, 2013, 2016, 2019; Eurostat (2022))

responses are necessary to properly address the setting policy measures. Examining the impacts at the regional or local level rather than the national level presents a notable difficulty due to the limited availability of both quantitative and qualitative data. It is necessary to underline that the present survey has some limitations, mainly related (but not limited) to measuring based on indicators defined from the literature review and data creating approach itself. It is impossible to refer to a complete collection since each of the most common databases has strengths and weaknesses. Limitations of the research related to own calculations and subsequent results lie in the scope of reference period and data availability, as well as calculations based only secondary data from official statistical sources were analysed. Due to the time and scope of the article, only internal factors of regional issues were analysed. The assumption is that external factors for all regions are the same. To improve the quality of the analysis, it is possible to include also qualitative data from surveys that will better characterise some of the competitiveness aspects. But collection of such data will need extra resources and time. Considering all these aspects, the article might not precisely reflect the entire research activity on regional issues in the last years, but the results suggested potentially interesting insights into the topics debated by scholars and highlighted the future frontiers of the domain. Further development of this research will involve both the methodological side and the specific domain under investigation. At the same time, more in-depth analyses on specific issues of regional issues will be performed to improve the knowledge on themes currently debated in the reference literature, like for example the role of sustainability and innovation. From the point of view of the regional resilience of the regions, it is possible to perceive the limits of the research primarily in terms of the fact that each economic shock has its own specific course, and its impact cannot be generalised for all types of economic shocks.

Conclusions

To best target the priority areas and adapt to the changing environment, public investments must be carefully chosen by local and regional authorities and policymakers. By making investments in the advancement of human capital, the modernisation of infrastructure, and the enhancement of business conditions, public intervention (particularly ESIF) can impact regional competitiveness. Since it is difficult to implement one-size-fits-all policies across all regions, it is crucial to capitalise on unique regional advantages and choose solutions that are appropriate for the various stages of development. However, to do this effectively, they need an adequate tool to monitor the impact of these measures, and the EC offers such a tool in the form of RCI. RCI presents a comprehensive view on the state of EU competitiveness at NUTS 2 regional level, balancing a variety of other important factors. Understanding how fiercely regions (territories/localities/areas or regions) compete, where this rivalry originates, and what factors influence territorial economic attractiveness are essential. With competitiveness as a starting point, comprehending territorial resilience issues enables us to consider the wealth generation of the territories, protect the welfare of all residents, promote sustainable economic growth, and manage economic shocks and decline in our territorial policies. Regional resilience, regional export orientation, business and corporate culture, regional institutional structure, and other aspects are clearly influenced by the type of state economic policy.

The 2020 epidemic has shaken every country, and no economy has been spared. With a strong territorial component, the COVID-19 issue has had a wide range of regional and local effects that have important implications for crisis management and policy responses. The COVID-19 pandemic has shown how important it is to build a robust system to deal with unanticipated shocks. The giant waves of the COVID-19 pandemic subsided no sooner than the Russian Federation invaded Ukraine. In addition to the humanitarian impact, the war significantly impacted European industry and trade. As a result, Europe is trying to wean itself off its dependence on Russian fossil fuels rapidly, and the prices of fuel and other (not only) energy raw materials are rising to record highs. At the same time, Putin's war in Ukraine is not replacing but further accentuating Europe's challenges before February this year. The COVID-19 epidemic has brought attention to the weakness of international supply networks and fuelled calls for increased European self-sufficiency in key goods and services.

Moreover, the war and the pandemic come at a time when the EU faces the challenges of green and digital transformation.

The policy of reorienting the EU economy in reaction to the Russian invasion of Ukraine, as well as of coordinated EU recovery response to the COVID-19 outbreak, should be centred on increasing resilience by design, not by tragedy. COVID-19's unequal distribution across the major European regions quickly sparked geographic worries about the pandemic's socio-economic, environmental, financial, and demographic components. While the national impacts of the COVID-19 crisis are widely recognised, comprehending its regional consequences will require additional time due to delays in reported data. Why was one location affected more severely than another? What explanations exist for geographical differences? Is it possible to draw connections between the territorial traits likely to affect a disease's propagation and those characteristics? These are the research-focused questions for additional study on the geographical effects of the current crisis, or crises.

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Examining climate change awareness and climate-friendly activities of urban residents: A case study in Košice

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Abstract: *As the impact of climate change begins to be felt all around the world, the vulnerability of urban areas due to their population density, high concentration of economic activities and the altered characteristics of the physical environment is becoming increasingly apparent. As a result, cities will play a crucial role in tackling climate change by fostering mitigation activities and managing and coordinating the adaptation process. Research has shown that engagement and awareness among citizens is vital in the promotion of effective adaptation policies, but studies have also drawn attention to the significance of the so-called "awareness-action gap," the absence of a direct link between awareness and action. This study contributes to the ongoing debate over the awareness-action nexus by discussing the factors that can affect the adaptation and mitigation activities of urban citizens using the Slovak city of Košice as a case study. Data was collected using a survey conducted with local residents as part of the preparations for the city's first adaptation strategy on climate change. The paper uses a two-step analysis to investigate the socio-economic, psychological and contextual factors associated with climate change awareness and climate-friendly activities. The results of the standard linear regression model indicate that self-assessed vulnerability is a determining factor in both the level of climate change awareness and the likelihood of individuals to take action. In the second step, we find that the factors which influence engagement in climate-friendly activities differ depending on the costs involved in implementing the activities. The exploratory analysis conducted using a machine learning algorithm suggests that the awareness-action nexus may be non-linear in nature. The main findings of this study imply that communication strategies should place a primary emphasis on individuals' vulnerability to the negative impacts of climate change. The paper contributes to the existing research by providing a case study of a generally under-researched geographical area of Central Europe. In addition, the analysis provides a specific context of urban area and implications for local policymakers, something that has been lacking the in literature looking primarily at data at the country level.*

Keywords: *Climate change awareness, citizen engagement, awareness-action gap, vulnerability, economic aspects of adaptation.*

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Introduction

Cities and urban residents have a crucial role to play in the development of climate change mitigation and adaptation. There are estimates that 50% to 80% of the measures which are necessary to mitigate the impacts of climate change require regional and local implementation and also suggest that the decisions of local governments can potentially influence up to one-third of all urban greenhouse gas emissions (OECD, 2021). The necessary public support of climate change policies is affected by people's environmental beliefs (Kácha et al., 2022). As a result, cities should make efforts to systematically raise awareness and involve governance factors as a standard procedure in adaptation efforts (Tapia et al., 2017). In order to do so, local policymakers must be well informed about the preferences of residents, their motivation and engagement in climate-friendly activities.

The aim of this paper is to examine the factors affecting engagement in adaptation and mitigation activities among individuals in the urban environment. Although cities are considered among the key actors of climate action, the existing literature on climate change awareness and action has primarily examined the issue at the national level or among specific socio-economic groups (Valenzuela-Levi et al., 2022). Moreover, little attention has been paid to specifically urban topics, such as the impact of heatwaves (Lenzholzer et al., 2020), which will be the greatest climate-related issue in many European cities. Additionally, there is a distinct lack of studies which have investigated urban awareness of climate change within the specific geographical context of Central and Eastern Europe. Individual nations and population groups often hold idiosyncratic views on climate change (Kácha et al., 2022), and regions embedded in various socio-economic and cultural milieus could form differing associations to climate change (Poortinga et al., 2019). Our study thus contributes to the existing literature by providing a novel perspective on climate change awareness and engagement in a local urban context.

Our study focuses on climate change awareness among the population of the city of Košice in Slovakia. We chose this city due to the fact that Central Europe, and especially urban areas, were under-represented in the previous research. The context of the post-socialist city with historically low citizen engagement might offer valuable insights into why some areas are lagging behind with their adaptation efforts. In addition, Košice is a city with a prominent industrial heritage, which also indirectly influences peoples' views on green transformation and sustainable futures. Being in this specific situation, the mechanism of climate change awareness and citizen engagement in climate friendly action might take on some specific context-dependent form.

Our case study offers an analysis of climate change perceptions and the adaptation and mitigation activities of city residents, the findings of which could serve as a first step in developing an effective communication strategy between authorities and local citizens. In the paper, we address the following questions. What factors influence the awareness of urban residents regarding climate change? What factors influence local citizens' engagement in climate-friendly activities? What is the connection between awareness and action? Do the factors differ depending on the cost of implementing the activities?

The paper is organized as follows: Section 1 offers a general description of the context and a literature review discussing the factors which influence attitudes to climate change, followed by a description of the data and methodology in Section 2. Section 3 applies regression analysis and the random forests model to analyze the data and presents a discussion of the main findings of the research, while the final section concludes with possible policy implications.

1. Theoretical background

1.1 Factors affecting climate change awareness and climate-friendly activities

Levels of climate change awareness have been found to differ across countries, contexts and individuals. A review by Gifford and Nilsson (2014) and a meta-analysis by Hornsey et al. (2016) offer a comprehensive list of the relevant factors which determine climate change beliefs and attitudes. The most intuitive characteristics relevant to climate change perceptions are the more sociodemographic aspects such as gender, age and education. People who accept the reality of climate change are usually younger, more educated and from higher income brackets, with the categories of gender or

race having a less significant impact on awareness. Climate change awareness also differs across countries (Poortinga et al., 2019). While a belief that human activities are contributing to climate change is a predictor of risk perceptions in Latin America and Europe, in Asia and Africa, changes in temperature are seen as the most prominent (Lee et al., 2015). Even the effect of education is not uniform across countries or among different political affiliations of citizens (Czarnek et al., 2021). In more developed countries, the topic of climate change is seen as a more politicized topic, and in such a context, education alone might not be enough to raise awareness about the risks of climate change, especially among right-wing voters (ibid). Differences were also identified between European countries, with the effects of demographic and socio-political factors found to be less significant in Eastern European countries than in Western states (Poortinga et al., 2019).

In addition to the sociodemographic and country-specific contexts, other factors that could be classified as psychological have been identified. The levels of subjective knowledge of scientific findings concerning climate change were largely the same for both "believers" and "sceptics," but a higher level of objectively measured knowledge is connected to a stronger belief in the reality of climate change (Hornsey et al., 2016). Personal traits such as open-mindedness, conscientiousness and lower emotional stability were also found to be related to environmental concerns (Gifford & Nilsson, 2014). Moreover, a willingness to support climate-related policies also stems from individuals' attitudes towards long-term planning or attachment to place (Alló & Loureiro, 2014), with those expressing a stronger attachment to global rather than national identities being more likely aware of climate change and hold a positive view towards climate change responses (Devine-Wright et al., 2015).

In terms of the magnitude of the effects, the socio-economic and psychological characteristics were overshadowed by variables connected to values, beliefs, political affiliation, worldviews and culture (Hornsey et al., 2016). One of the most important factors is that of social identity (ibid); individuals who identified with a "green" or activist identity or who stated that they valued the natural environment were more likely to believe in the reality of climate change.

Theories of risk perception tend to suggest that personal experience would be expected to affect perceived risk and that the personal relevance of the issue would have a greater effect than a reliance of cognitive information (Howe et al., 2014). As was shown in a meta-analysis by Alló and Loureiro (2014), a direct experience of extreme weather events increases the willingness to accept the costs of mitigation and adaptation policies. Other empirical research has shown that although personal experience with extreme weather conditions and their impacts is connected to a stronger belief in climate change, this association is not considered to be particularly significant (Hornsey et al., 2016). Sometimes, even individuals who have had direct experience with extreme weather events are not necessarily convinced of the need to adopt policies directed at climate change mitigation and adaptation (Gärtner & Schoen, 2021). Interestingly, this relationship also functions inversely, as our perception of our experiences can be influenced by our beliefs, with individuals' opinions about global warming influencing their likelihood of recollecting extreme weather events (Kácha et al., 2022). A feedback mechanism between climate change perceptions and negative effects has also been identified, which suggests that people process cognitive information and affect heuristics simultaneously (Linden, 2014). A perceived susceptibility to climate change was found to be connected to a greater willingness to engage in mitigation activities (Semenza et al., 2011). The phenomenon of self-reported heat stress in urban residents and its associations with coping strategies was the subject of a study by Kunz-Plapp et al. (2016) but the results were inconclusive. This is why more research focused on the relationship between vulnerability and action in urban environment is needed.

1.2 The awareness-action gap

Earlier research into translating perceptions to actions has shown that belief in climate change alone is not a sufficient predictor of the adoption of environmentally friendly activities; indeed, studies suggest that belief is more connected with an intention to act than with actual activity (Hornsey et al., 2016). Perhaps the most methodologically comprehensive and statistically robust work carried out on the topic to date is the paper by Saari et al. (2021), which illustrates that environmental risk perception and

environmental knowledge, mediated by environmental concerns, can be translated into behavioral intention and realization.

In general, one of the more perplexing findings of research into this issue is the complexity of the translation mechanisms from awareness and action, with some studies even refuting the idea that there is a direct link between awareness and action. A number of studies have already shown that awareness of climate change and its impacts offers no accurate prediction of the likelihood of adopting climate-friendly activities, an effect which has been termed the "awareness-action gap" (Csutora, 2012) or the attitude-behavior gap (Farjam et al., 2019). This disparity between different components of environmental awareness is a consequence of the complex nature of reality and economic-structural factors (Csutora, 2012), such as the embeddedness of individual behavior within social and institutional contexts (Jackson, 2005) or the unwillingness of consumers to relinquish unsustainable lifestyles perpetuated by social norms (Sanne, 2002).

1.3 Economic aspects of climate-friendly activities

Previous studies have suggested that varying costs of climate-relevant behavior can have an impact on the adoption of such measures. Some theoretical background is offered in the low-cost hypothesis, which postulates that behavioral costs can influence the effects of attitudes on behavior (Diekmann & Preisendörfer, 2003). In addition to the financial aspects, costs can be viewed in terms of time, discomfort or effort expenditure. According to Diekmann and Preisendörfer (2003), environmental concerns tend to influence ecological behavior to a greater extent when associated with lower costs and inconvenience. Attitudes are more likely to translate into corresponding behavior when the actions are uncomplicated and affordable, but environmental concern alone is insufficient to overcome barriers associated with behaviors that entail high costs or considerable levels of inconvenience (ibid). In such cases, education and financial resources might mediate the connection between belief and action (Stern, 1992). Engagement in low-cost climate-friendly behaviors has been shown to be positively related to factors such as age, levels of concern and the perception of climate benefits (Tobler et al., 2012). In the case of high-cost activities, government bodies could play a role in introducing incentives and cost-reducing measures to motivate climate-friendly actions (Jakučionytė-Skodienė & Liobikienė, 2022).

A correlation has been identified between climate action and environmental injustice (Castán Broto & Westman, 2020). Individuals with lower financial resources encounter barriers in participating in climate-friendly actions as they typically lack the means to invest in expensive measures but also lack access to more affordable activities. In light of this, research into local climate adaptation action has shifted towards poverty-alleviation agendas which are focused on addressing socio-economic disparities and the issue of marginalization. The aim is to examine ways of fostering deeper inclusion and equity within urban climate governance.

1.4 Case study background: Košice

Based on a recent study conducted by the OECD (2023) and the Institute of Environmental Policy of the Slovak Ministry of Environment containing an assessment based on 10 levels of risk, Košice in particular, has been identified as a high-risk district, primarily due to its higher risk of drought (level 8) and extreme heat waves (level 6). In contrast, the risk of extreme precipitation in Košice is relatively low, rated at level 3. Extreme heat was also identified as the most salient climate-change related issue in Košice in studies from the European Environmental Agency (European Environment Agency, 2020), which compiled a list of the observed and projected impacts for seven types of biogeographical regions in the EU. When it comes to conditions for climate action, there is an industrial heritage connected to the still active steel industry and several disused industrial brownfield sites, an environmental burden which poses a challenge (or an opportunity) for future adaptation policies.

In 2022, Košice introduced its first adaptation plan for climate change for 2022–2030, which builds upon vulnerability assessments and recommends specific goals in the climate change adaptation process. The effort to pursue a more sustainable future is also manifested in the city's application for the European Green Capital Award and its participation in the 100 Climate Neutral Cities 2030 initiative. Since 2019, Košice has also been part of the Covenant of Mayors for Climate and Energy initiative, pledging to reduce GHG emissions and

to increase climate change resilience through adaptation strategies. One distinctive aspect of the city lies in the limited engagement of local residents in political participation, a trend which is particularly evident in data concerning local elections. In 2022, Košice recorded the lowest voter turnout for local self-government and mayoral elections when compared to eight cities of similar size and nature. Only 31% of residents participated in the local elections, whereas the average participation rate across the other eight cities stood at 41.2%, with a median of 39.3% (Statistical Office of the Slovak Republic, 2022).

2. Research methodology

The data analyzed in this paper originates from a survey which was primarily conducted in an online format among the residents of Košice from October 2019 to January 2020. The questionnaire was accessible through social media, the web page of the KOŠICE ± 40 project and the web pages of the partners of the project, and information about the questionnaire was also sent by the municipal authorities to all affiliated municipal institutions with the request that it be distributed among their employees. The questionnaire was also distributed to 100 businesses in Košice and was made available in physical format for use in schools and retirement homes. For the purposes of this analysis, only the responses received from Košice residents were considered, with the total dataset consisting of 545 valid responses.

The questionnaire contained questions concerning sociodemographic characteristics such as age, income, education, sex, household size and overall levels of satisfaction. The main focus was placed on attitudes towards climate change, respondents' personal experience with its impact, satisfaction with the availability of information on the topic and measures concerning climate change impacts. The study also aimed to identify the types of climate-friendly activities in which local residents engaged and to gauge their participation in local politics.

Tab. 1 lists a statistical breakdown of the questionnaire respondents. From a demographic perspective, the age of respondents ranged from 15 to 87, with both a mean and median age of 40. Most of the respondents stated that they belonged to the middle-income group. There were slightly more women than men, and most of the respondents had children. Participants stated that they were generally satisfied with their lives. As the survey was voluntary, most of the respondents had a pre-existing interest in the topic of climate change, and this

Tab. 1: Descriptive statistics

Variable	Min	Max	Mean	SD	Median
Age	15.0	87.0	40.2	14.8	40.0
Income	1.0	3.0	2.0	0.5	2.0
Education (years of schooling)	10.0	18.0	16.3	2.4	18.0
Sex (0 = male)	0.0	1.0	0.6	0.5	1.0
Children (0 = no children)	0.0	1.0	0.6	0.5	1.0
Life satisfaction	1.0	5.0	3.9	0.7	4.0
Interest in climate change	0.0	1.0	0.9	0.2	1.0
Subjective vulnerability	0.0	1.0	0.5	0.2	0.5
Citizen engagement	0.0	1.0	0.4	0.2	0.4
Information	0.2	1.0	0.5	0.2	0.5
Engagement in climate-friendly activities	0.0	1.0	0.6	0.2	0.7
Satisfaction with measures	0.0	1.0	0.4	0.2	0.4
Awareness	0.1	1.0	0.8	0.2	0.8

Source: own

resulted in a potentially biased sample with an overrepresentation of people with a stronger interest in the topic.

The focus of our analysis was placed on gaining an understanding of the factors that impact awareness and engagement in climate-friendly activities. This was achieved by formulating nine climate-related variables which were subsequently examined in our models; these variables are listed in Tab. 2.

The variables were examined using the sociodemographic indicators as control variables. The variables were mostly created in the form of indices compiled from the Likert scale responses to the statements provided on the topic.

Tab. 2: Climate-related variables

Variable	Type	Description	Questionnaire item (example in the case of multiple sub-questions)
Awareness	Average score from 2 questions – knowledge and seriousness (see below), adjusted by min-max normalization	(See below)	(See below)
Knowledge*	Index based on the summed scores from 10 statements with Likert scale responses (5 levels), adjusted by min-max normalization	Statements concerning anthropogenic causes of climate change, scientific consensus on climate change, and impacts of climate change	Research shows that climate change is caused by human activity
Seriousness*	Likert scale score (10 levels), divided by 10	Degree of seriousness of climate change as an issue	How serious a problem do you believe climate change to be at the moment?
Vulnerability	Index based on the summed scores from 8 statements with Likert scale responses (5 levels), adjusted by min-max normalization	Statements concerning negative climate change impacts on health, agriculture, infrastructure and property, services or business	Summer heatwaves reduce my work performance (focus/attention)
Engagement	Index based on the summed scores from 8 examples with Likert scale responses (3 levels), adjusted by min-max normalization	Examples of activities indicating engagement in local politics	I participate in local elections
Information	Average score from 2 questions with Likert scale responses (5 levels), adjusted by min-max normalization	Degree of satisfaction with available information concerning climate change impacts and adaptation options	1) Do you feel sufficiently informed about climate change and its impact on Košice? 2) Do you feel sufficiently informed about how to adapt to climate change in the city?
Interest in climate change	Dummy	Interest in climate change	Are you interested in the topic of climate change?
Satisfaction with measures	Index based on the summed scores from 15 examples with Likert scale responses (5 levels), adjusted by min-max normalization	Satisfaction with adaptation measures which are done by the local authorities, primarily in public spaces	E.g., air-conditioning in public buildings (including hospitals)
Climate-friendly activities	Index based on the summed scores from 17 examples (Tab. 4) with Likert scale responses (5 levels), adjusted by min-max normalization	Examples of activities related to adaptation and mitigation	See Tab. 4.

Note: *variable not used directly in the model.

Source: own

Tab. 3 shows the categorization of climate-friendly activities based on their associated costs. It lists all provided climate-friendly activities divided into two categories, based on which dependent variables were created. These groups were assigned intuitively – low-cost activities are mostly behavioral adjustments, such as following extreme weather alerts or sorting the waste for recycling. High-cost activities include examples that are associated with certain material and/or financial resources, such as having air conditioners.

Tab. 3: Climate-friendly activities

	Activity
Low-cost activities	I support the maintenance of green spaces instead of new buildings and parking spaces
	I spend most of my time outside the city (e.g., at a cottage, in the countryside) during hot days
	I compost my bio-degradable waste
	Instead of a private car, I use alternative means of transport which are more sustainable for the environment (walking, bicycle, public transport or car-sharing)
	I drink enough water, keep myself cool and avoid direct sunlight during heatwaves at noon
	Whenever possible, I buy local products and seasonal produce
	I try to minimize my waste production, e.g., by limiting the use of plastic bags
	I sort waste for recycling
	I engage in volunteering activities dedicated to the protection of the environment
	I follow extreme weather alerts
High-cost activities	I use air-conditioning during hot days
	Low fuel consumption was an important feature that I considered when buying a new car
	I changed my holiday plans due to heatwaves (different dates or locations)
	I installed additional shading equipment at home
	I insulated my house/apartment in order to reduce temperate fluctuations
	Whenever possible, I prefer to maintain green spaces on my property

Source: own

In order to analyze the data, we first ran a standard linear model examining the associations between the dependent and explanatory variables while monitoring the effect of the socio-economic factors. We created four OLS models with different dependent variables. The models were checked for multicollinearity and the results were negative. If any heteroskedasticity was detected, robust standard errors were reported. The four regression models were specified as follows (Equations (1–4)):

Model 1:

$$Awareness_i = \beta_0 + \beta_1 * sociodem_i + \\ + \beta_2 * Interest_i + \beta_3 * Vulnerability_i + \\ + \beta_4 * Engagement_i + \beta_5 * Information_i + \\ + \beta_6 * Activities_i + \beta_7 * Measures_i + \varepsilon_i \quad (1)$$

Model 2:

$$Activities_i = \beta_0 + \beta_1 * sociodem_i + \\ + \beta_2 * Interest_i + \beta_3 * Vulnerability_i + \\ + \beta_4 * Engagement_i + \beta_5 * Information_i + \\ + \beta_6 * Measures_i + \beta_7 * Awareness_i + \varepsilon_i \quad (2)$$

Model 3:

$$Activities(cheap)_i = \beta_0 + \beta_1 * sociodem_i + \\ + \beta_2 * Interest_i + \beta_3 * Vulnerability_i + \\ + \beta_4 * Engagement_i + \beta_5 * Information_i + \\ + \beta_6 * Measures_i + \beta_7 * Awareness_i + \varepsilon_i \quad (3)$$

Model 4:

$$Activities(expensive)_i = \beta_0 + \beta_1 * sociodem_i + \\ + \beta_2 * Interest_i + \beta_3 * Vulnerability_i + \\ + \beta_4 * Engagement_i + \beta_5 * Information_i + \\ + \beta_6 * Measures_i + \beta_7 * Awareness_i + \varepsilon_i \quad (4)$$

where: *sociodem* – the set of sociodemographic variables described in Tab. 1; *Awareness, Interest, Vulnerability, Engagement, Information, Activities, Measures* – the variables described in the Tab. 2 and Tab. 3; β_0 – the regression intercept; β_{1-7} – coefficients corresponding to the explanatory variables; ε – error.

The second methodological approach applied an exploratory technique using a machine learning algorithm which was used to validate the regression results and indicate non-linear relations between the investigated concepts. The random forest (RF) technique developed by Breiman (2001) was applied in this process. Our study adopted a bagging algorithm using the "randomForest" R Package based on Breiman and Cutler's random forests for classification and regression. The parameters were set as follows: first, the number of trees to grow was set to 500, and the number of variables randomly sampled as candidates at each split was set to 5. After running the model, the out-of-bag mean squared error stabilized at around 150 trees and there was no additional gain in increasing the number of trees. This method was applied in order to identify any potential hidden relationships that could not be described by the standard linear model. This was intended as an exploratory step to either confirm the results of the previous models or to suggest further improvements in potential future research. As there was no intention to make inference statements, it was not considered necessary to divide the data into the training and testing sets. Similar machine learning algorithms have been used in other studies, e.g., by Lee et al. (2015), which examined the predictors of climate change awareness and risk perceptions in different countries. The study selected this method due to its high predictive accuracy and capacity to provide an unbiased and robust ranking of predictor importance and account for complex interactions between predictors and unbalanced response classes while preserving as much information in the data as possible. The analysis also avoided the need to divide the sample into training and testing sets, as the prediction accuracy for each model was calculated using a built-in out-of-bag test sample provided in the R function of the package (this option was also selected in our analysis).

3. Results and discussion

3.1 Results

The results from the first model examining factors associated with climate change awareness revealed several key findings. The most significant explanatory variable was subjective vulnerability, indicating that individuals who perceived themselves as vulnerable to the impacts of climate change were more likely to be aware of the issue. Additionally, interest in the topic of climate change emerged as an important factor, suggesting that individuals with a general interest in climate change were more likely to be aware of its implications. The results also indicated a negative relationship between age and awareness, indicating that younger people tended to be more concerned about climate change. Overall, the model accounted for 27% of the variance in the dependent variable. The findings indicate that individuals who are aware of climate change are typically younger, have an existing interest in the topic, and have personally experienced the effects of climate change in their everyday lives.

Several significant predictors were identified in the second model, which explored the factors associated with engagement in climate-friendly activities encompassing both mitigation and adaptation measures. Citizen engagement emerged as the most effective predictor, suggesting that individuals who actively participated in climate-friendly actions were more likely to engage in such activities. Subjective vulnerability also played a significant role, indicating that those who perceived themselves as vulnerable to climate change were more likely to engage in climate-friendly actions. Age and satisfaction with the information provided on climate change and adaptation strategies were positively associated with the dependent variables, suggesting that older individuals and those who felt adequately informed were more likely to engage in climate-friendly activities. Gender was also a relevant factor in this model, with male respondents displaying a more negative association, although the significance level was relatively low. Overall, the model accounted for 30% of the variance in the dependent variable. The results from this model suggest that individuals who engage in climate-friendly

Tab. 4: OLS results

	Estimate, std. error and significance			
Variables	**Awareness**	**Activities**	**Activities (cheap)**	**Activities (expensive)**
Intercept	0.484 (0.066)***	0.103 (0.076)	0.278 (0.077)***	−0.131 (0.098)
Age	−0.002 (0.001)**	0.002 (0.001)**	0.001 (0.001).	0.002 (0.001)**
Income	0.026 (0.016).	0.017 (0.013)	−0.012 (0.013)	0.059 (0.019)**
Education	0.003 (0.002)	0.000 (0.003)	0.000 (0.003)	0.000 (0.004)
Sex (male)	−0.022 (0.013)	−0.033 (0.014)*	−0.048 (0.013)***	0.000 (0.018)
Children	−0.012 (0.016)	0.008 (0.017)	−0.027 (0.016).	0.063 (0.023)**
Life satisfaction	−0.006 (0.009)	0.014 (0.010)	0.011 (0.009)	0.014 (0.012)
Interest in climate change	0.209 (0.030)***	0.046 (0.037)	0.050 (0.038)	0.027 (0.040)
Subjective vulnerability	0.217 (0.039)***	0.178 (0.038)***	0.086 (0.036)*	0.286 (0.047)***
Engagement	−0.007 (0.040)	0.264 (0.034)***	0.289 (0.033)***	0.156 (0.041)***
Information	−0.001 (0.007)	0.017 (0.007)*	0.023 (0.007)**	0.018 (0.049)
Activities	0.084 (0.058)			
Satisfaction with measures	−0.068 (0.044)	0.084 (0.050).	0.064 (0.051)	0.095 (0.058).
Awareness		0.093 (0.064)	0.117 (0.063).	0.031 (0.063)
N	545	545	545	545
Adjusted *R*-squared	0.275	0.307	0.296	0.199

Note: Significance codes: *** 0; ** 0.001; * 0.01; . 0.05.

Source: own

activities are more likely to be women who are active citizens with personal experience of the negative effects of climate change and feel that they have sufficient information on adaptation measures. Additionally, the level of engagement tended to increase slightly with age.

The third model focused on climate-friendly activities that are inexpensive or cost-free. Similar to the previous models, citizen engagement emerged as a significant factor, indicating that individuals who actively participate in these low-cost activities were more likely to engage in climate-friendly behaviors. Vulnerability and satisfaction with information also played relevant roles, suggesting that individuals who perceived themselves as vulnerable to climate change impacts and felt adequately informed were more likely to engage in such activities. Gender showed a high significance in this context, although the magnitude of the effect was not substantial. The model accounted for approximately 30% of the variance in the data. This model suggests that individuals engaging in inexpensive climate-friendly activities are likely to be women who are also involved in local politics and do not perceive a lack of available information on adaptation measures.

The predictive power of vulnerability and citizen engagement remained high in the fourth model, which examined expensive climate-friendly activities, but a new variable emerged as relevant: the parental status of respondents. Individuals with children were found to have a higher likelihood of engaging in expensive climate-friendly activities. Additionally, higher incomes and advanced age were associated with an increased likelihood of participating in these activities.

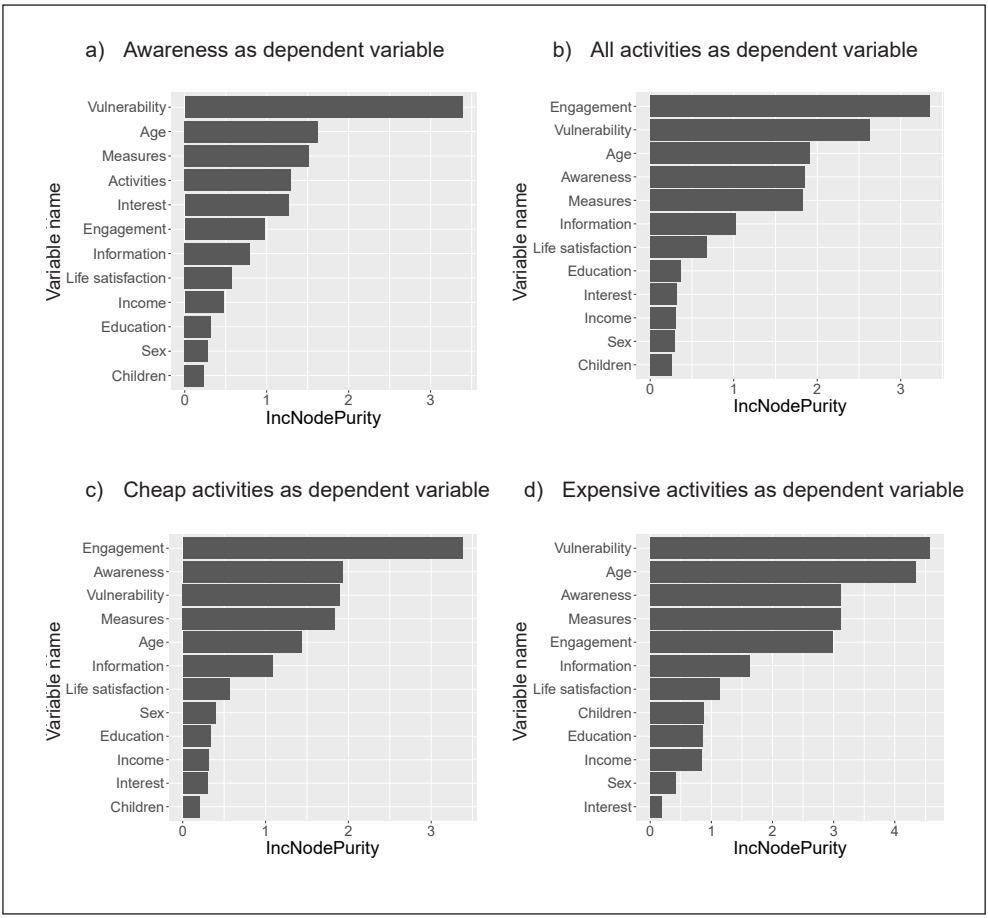

Fig. 1: Importance of variables in random forests models

Source: own

Overall, the models did not identify a high proportion of variance in the dependent variable, as the adjusted *R*-squared rate was between 0.2–0.3. However, it should be noted that this is a common occurrence in social science research, and similar studies achieve comparable values in this metric (e.g., Rosentrater et al., 2013; Shi et al., 2015).

The final part of the analysis examined possible non-linear relationships between the dependent and explanatory variables. The direction of the relationships was not the main focus of this analysis as this characteristic cannot be identified using the random forests algorithm. The random forests model can be interpreted using feature importance values which are relative in the model and are therefore not numerically significant. These values are used to rank the input variables that influence the target variable. The random forests algorithm allows us to identify the variables most responsible for decreasing variance through node purity, thereby determining the most important features for predicting the dependent variable. The derived feature importance is shown in Fig. 1a–1d as IncNodePurity, a value representing the total decrease in node impurities measured by the Gini index. The expressed measure relates to the decline in purity when a specific variable lacks information. In scenarios where a variable

possesses no initial information, the resultant decline would amount to zero.

The first random forests model examines the predictors associated with "awareness" (Fig. 1a). The most important independent variable is that of self-assessed vulnerability, followed by age and satisfaction with measures. Among the least important variables are sociodemographic characteristics "children," "sex," "education" and "income."

The results of the second model (Fig. 1b) confirmed that citizen engagement in local politics ("engagement"), vulnerability and age might help explain the variance of climate-friendly actions. Satisfaction with local adaptation measures (the "measures" variable) was also found to be a good predictor of climate-friendly action. In contrast to the findings of the regression results, awareness was only the fourth most important variable, although it is at a comparable level of importance with age and satisfaction. This suggests that awareness might still matter but that the relationship cannot be described by a linear model. With the exception of age, the sociodemographic variables were assessed as having low predictive power.

The two models investigating the predictors of engagement in the case of low and high cost climate-friendly activities differ slightly in their results (Fig. 1c–1d). Corroborating the results from the OLS, engagement in politics was found to play a crucial role in explaining engagement in cheaper climate-friendly activities. Subjective vulnerability, awareness and satisfaction with measures showed broadly similar levels of importance. Employing expensive measures was associated with vulnerability and age, followed by satisfaction with measures, awareness and engagement in local politics. The low-cost hypothesis could not be reliably confirmed by the above models, as awareness ranked among the most important variables for both low and high cost activities. As with the regression results, age plays a more important role in explaining engagement in high-cost activities rather than cheaper measures. This could be due to the straightforward correlation of age and wealth rather than income, a value which was controlled for in the analysis.

3.2 Discussion

Our analysis not only confirms the previous findings on the factors affecting climate change awareness and action in general, but also sheds light on the topic in the under-researched context of the urban environment and relates it to engagement in local politics. The significance of sociodemographic attributes, notably age, sex, income and parental status outlined, e.g., in Gifford and Nilsson (2014) or in Hornsey et al. (2016), was validated across various model specifications. The role of age was evaluated as highly important in the non-linear models but as somewhat less salient in the linear analyses. This interpretation is in agreement with earlier research into the prediction of climate change awareness, which also indicated that awareness was more profound in the case of younger people (Hornsey et al., 2016). The nature of the results relating to the prediction of action is even clearer when activities are divided in terms of cost, with age becoming positively associated with a higher probability of engaging in more expensive activities. This interpretation is intuitive when we examine the specific activities that were included in the survey, such as making home improvements, choosing vacation destinations, or buying a new car, activities that are naturally more typically associated with later adulthood than with young age. Furthermore, the positive coefficients associated with income and having children which were noted in the case of expensive activities, are also intuitive. These characteristics were only found to be relevant in this one model, which suggests that parents with higher incomes have the means and/or the motivation to engage in more costly adaptation-related activities. In the previous literature, income was found to be positively correlated with climate change beliefs (Hornsey et al., 2016).

One aspect of the findings which differed from those of earlier studies was the level of education; this factor was not found to be relevant in any of the models in our study. This missing link perhaps deserves further research that considers the specific conditions of different education systems. The findings suggest that in Slovakia, a post-socialist country which still enjoys a significant degree of egalitarianism in its education system, the influence of education may be less significant than in other countries. Or, as suggested by Czarnek et al. (2021), the effect of education could be dependent on the political ideology and/or the level of the country's development. This could mean that Slovakia is among the developed countries, where the positive effect of education is attenuated by the right-wing ideology.

On the other hand, our research did confirm the connection between sex and engagement in climate action. We found that women were more likely to take part in low-cost mitigation and adaptation activities, a finding which could be explained by earlier research which has associated the different stances towards adaptation to climate change among male and female respondents to the factor of motivation – men are more likely to be motivated by financial reasons and advances in technology, while women tend to be more egalitarian and prioritize the community and ecological aspects of measures (Alló & Loureiro, 2014; Brink & Wamsler, 2019).

In the case of psychological factors, we found that personal experience with negative impacts of climate change in everyday life is of great importance in both awareness and all types of activities. In the literature, this relationship has been found to vary, with some studies postulating that experience increases support for climate policies (Alló & Loureiro, 2014), while others finding that some people do not find their experience convincing of the need to adopt policies directed at climate change mitigation and adaptation (Gärtner & Schoen, 2021). In addition, a cognitive aspect to the awareness-action gap was identified. This is in line with the hypothesis that personal experience is also responsible for shaping human behavior rather than cognitive information alone. This means that in order to become fully aware and willing to take action, urban residents need to internalize not only their knowledge of the issue, but also the connection between their negative experiences and the reality of climate change. In addition, the availability of information about how to adapt to climate change has been found to motivate low-cost behavior. This finding is in line with those reported by Shi et al. (2015) which identified a nexus between action-related knowledge (in our case, information about possible ways of adapting) and a willingness to adjust behaviors.

In practice, the findings of the study are of great importance for policymakers' communication strategies. The information that stresses the direct relationship between climate change and peoples' exposure to the consequences of heatwaves, flash floods, or drought will be the most efficient means of conveying the desired message and motivating action among local populations. Indeed, by providing guidance on how to mitigate the impacts of climate-related changes, local authorities could also foster further activities. However, in order to gain support for climate change policies, the authorities should communicate through causal knowledge and avoid interfering with peoples' cultural values (Shi et al., 2015). In addition, result-oriented communication focusing on the uncontrollable consequences of climate change should be avoided, as this could engender feelings of resignation and helplessness (ibid).

Another important aspect to consider when designing policies and communication strategy is the economic cost of climate-related adaptation and mitigation activities. This aspect of the issue increases in importance when we take into account the urgency of costly adaptation measures. Although we found that the availability of information on adaptation measures might help to motivate engagement in low-cost activities, it is imperative to consider the potential downsides of such an approach, with engagement in low-cost behaviors potentially undermining more expansive efforts to mitigate climate change through costly yet effective action (Hagmann et al., 2019). Environmentally concerned individuals reduce the cognitive dissonance between their attitudes and the impacts of their actions through low-cost behaviors, which subsequently lessens their need to engage in costly behaviors. Attempts to offer quick fixes to complex problems such as climate change always have the potential to backfire and result in unforeseen consequences (ibid).

Additionally, the connection to climate justice is an important aspect to consider in the interpretation of the results. Climate justice emphasizes the equitable distribution of the burdens and benefits of climate change and the fair participation of all individuals and communities in decision-making processes. In the context of local climate governance, it is crucial to assess whether certain demographic groups, particularly those who may be more vulnerable to the impact of climate change, have equitable access to information, resources, and opportunities for engagement in climate-friendly activities. Our case study indicated lower levels of involvement among older sections of the population.

Earlier studies have emphasized the importance of identity (Hornsey et al., 2016), and this can also be implied from our results concerning the impact of engagement in local

politics. Active participation in local political and civic life greatly increases the likelihood of engagement in climate-friendly activities. We can also suggest the possible existence of an "activist" identity that, although it could not be measured directly in the survey, can still be discerned in the observed data. When designing measures, local policymakers can capitalize on the motivation of these already active citizens, who can serve as inspirational role models for their communities. Further research on climate perceptions and climate-friendly behavior in cities could further explore how to build upon the connection between attachment to place and action. Promotional activities related to building a city's brand and identity could potentially enhance local citizens' engagement in climate-friendly activities. Additionally, this could suggest that supporting civil society represents an indirect contribution to the fostering of adaptive activities. Allocating resources to community-building initiatives and promoting participatory climate governance is particularly effective in cities with lower levels of citizen engagement, such as Košice.

There are limitations connected to the sample and the sampling method employed in the survey. Although our data is derived from a relatively large sample of questionnaire responses, the sample was potentially biased as many of the respondents to the questionnaire showed a pre-existing interest in the topic of climate change. People with higher educational attainments were also overrepresented in the sample, and there were relatively few respondents from low-income brackets. As a result, future research should ensure that respondents are selected irrespective of their interest in the topic and should also make an effort to include marginalized groups. Previous research has also shown that awareness and action can be heavily influenced by pre-existing values and identities, and therefore, surveys which aim to map climate change perceptions should also attempt to collect responses on these topics in order to ensure a more balanced dataset.

Conclusions

The identification of the co-founding factors of climate change awareness and subsequent action represents a crucial step in understanding the mechanisms which should be employed in order to ensure the successful adoption of adaptation and mitigation policies across different demographic groups. Our study not only confirms the general principles identified in earlier research but also offers a specific context related to urban residents and local politics. The main contribution to the existing literature is twofold – first, by accounting for the local context, we addressed the debate on climate change adaptation at the most important level – cities. Second, by choosing Košice, we provided a case study of the under-researched geographical area, which has its specific conditions.

As for the comparison with the existing research, the analysis has confirmed multiple sociodemographic characteristics outlined in e.g., Hornsey et al. (2016) as having an impact on either awareness or engagement in climate-friendly activities. Those with higher awareness levels tend to be younger and those more engaged are usually women. The missing link between education and climate beliefs can be explained by politization of the topic in developed countries (Czarnek et al., 2021). Our findings on the role of subjective vulnerability contributes to conflicting results of the previous researchers, e.g., Kunz-Plapp et al. (2016) or Gärtner and Schoen (2021), indicating that own experience with negative impacts might indeed motivate people to act. When it comes to the previous research on the economics aspects, attitudes were found to be more likely to translate into corresponding behavior when the actions were uncomplicated and affordable, but environmental concern alone was found to be insufficient to overcome barriers associated with behaviors that entail high costs or considerable levels of inconvenience (Diekmann & Preisendörfer, 2003). Our analysis could not completely confirm this (due to borderline low significance level), but we found that having information matters when it comes to low-cost measures.

The results of the study draw attention to several policy implications. As the findings suggest that cognitive awareness alone might not be sufficient to motivate people to act, awareness-raising campaigns should not necessarily be seen as the most effective means of achieving higher levels of engagement and it might be more effective to confront people with the impacts of climate change through their own experience and vulnerability. As a result, approaches which place a greater

emphasis on the direct connection between climate change and its immediate manifestations in the local environment and on peoples' everyday lives could potentially motivate local residents to become more actively involved in mitigation and adaptation activities. As previous studies have suggested, the availability of action-related information was found to affect individuals' willingness to act. This means that communication strategies should also include recommendations for specific climate-friendly activities and their potential effect.

We also identified a connection between climate-friendly action and participation in local politics, but we do not view this nexus as a causal relationship but rather as co-occurring phenomena, a correlation which could be a manifestation of an as-yet undetermined activist identity. From this perspective, participatory community-building activities organized by local stakeholders ranging from local authorities to NGOs or other actors could encourage those who hesitate to engage on their own, an approach which might be more effective than campaigns focused on raising awareness. The sense of identity engendered by belonging to a group with an activist identity can also promote citizen engagement in a broader sense.

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Educational attainment as a predictor of poverty and social exclusion: Empirical analysis of Serbian case

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Abstract: *This study examines the impact of education on the risk of poverty and social exclusion in a single-country framework. Relying on household and individual level data from the annual EU-SILC survey obtained in Serbia in 2020, we estimate the market and non-market benefits of education in the context of combating poverty and social exclusion in developing countries. Based on a representative sample of the adult population in Serbia, we explore to what extent the risk of poverty and social exclusion can be predicted by the levels of educational attainment. Econometric estimations indicate that educational underachievement acts as a significant driver of poverty and social exclusion. Probit regression analysis indicates that the risk of experiencing poverty and social exclusion decreases substantially with higher education levels. We include three model specifications that calculate the predicted probability of being at risk of poverty, severely materially deprived and exposed to combined risks. Holding other predictors constant, the decrease in poverty and social exclusion probability attributed to a one level increase in educational attainment amounts up to 7.96% (for unemployed women with only primary education). The analysis confirms that the highest gains from schooling are materialized for the categories of respondents who are not active in the labor market and those with the lowest levels of educational attainment. Besides this, self-perceived health and labor market activity significantly affect the risk of poverty, material deprivation and social exclusion. The impact of age differs across our model specifications, indicating that age increases the probability of severe material deprivation and the combined risk of poverty and deprivation, while older age appears to go in hand with a lower risk of poverty itself. These results offer relevant information that should be considered when determining the optimal level of social investment in education.*

Keywords: *Poverty, social exclusion, education, Serbia.*

JEL Classification: *I32, D63, P36.*

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Introduction

The potential contribution of human capital to economic growth and social well-being has been the subject of extensive academic research, resulting in diverse and widely debated results. One line of research focuses on market-based outcomes of investing in education, drawing upon the human capital theory (Becker, 1964; Mincer, 1962) and the assumptions that higher educational attainment results in productivity increases, which are ultimately reflected in higher earnings. Other studies,

drawing upon the theory of endogenous growth (Barro, 2001), emphasize market returns of schooling at the level of society at large. Educational underachievement is widely recognized as both the cause and the consequence of household poverty and social exclusion (Atkinson, 1998; Comer, 1988; Levitas, 2006). Education helps economically and socially marginalized and deprived adults and children to escape poverty traps and engage in productive social activities. Numerous studies indicate that children who grow up in poverty are more likely to experience emotional problems, adverse health conditions, problematic behavior and low educational outcomes in adult life (Bolger et al., 1995; Haveman & Wolfe, 1995). Some of them (Feinstein, 1998) confirmed that educational underachievement is a key mechanism of turning early-life deprivation into poor achievements later in life, increasing the risk of social exclusion. This is not to exclude the numerous potential determinants of poverty and social exclusion, whose intertwined effects are very complicated to identify and measure. The comprehensive assessment of both market and non-market returns to education represents an invaluable input for determining the optimal level of social investment in education (Haveman & Wolfe, 2002).

In this study, we focus on the private market and non-market benefits of education, aiming to contribute to the literature on the determinants of poverty and social exclusion. We perform a single country study belonging to the region of Western Balkans, as the efforts to reduce poverty and social exclusion in the countries of the region are even more important due to the more pronounced and persistent problems of socio-economic development than in any European country. The educational outcomes of the Western Balkan countries are known to be among the lowest in Europe, with pronounced education inequalities between socio-economic groups. The labor markets in these countries cope with considerable skills mismatch and underutilization of labor. Serbia, among the countries of the region, represents an example of an economy facing significant challenges in developing social infrastructure while coping with considerable social and economic inequalities. Such developments confirm the specific importance of exploring the links between education and socio-economic disadvantages. Relying on household-level analysis, we examine the impact of educational attainment on the risk of poverty or social exclusion in Serbia. By analyzing data from the Survey on Income and Living Conditions (EU-SILC), we tend to identify significant relationships between the levels of individual educational attainment and the risk of poverty and social exclusion. We hypothesize that higher levels of educational attainment are associated with a lower risk of poverty or social exclusion and analyze the underlying factors accounting for the variance in the risk rates. Evidence on these issues has important implications for public education policies and the optimal financing of educational services.

This paper is organized as follows: Section 1 reviews the context for the research by discussing the importance of education for combating poverty and social exclusion, along with a review of literature on the various market and social benefits of education. Section 2 describes the data, choice of variables and estimation methods. Section 3 presents and discusses the results of empirical analysis. Section 4 summarizes the findings and offers concluding remarks.

1. Theoretical background

1.1 Market and non-market benefits of education

The dominant approach in the analysis of the returns to education relies on the human capital theory (Becker, 1964; Mincer, 1962). From this perspective, knowledge and skills obtained through education or training increase the productivity of individuals, which then materializes into higher earnings as returns to education. Higher educational attainment is assumed to increase the likelihood of securing a well-paid job and avoiding unemployment (Kampelmann et al., 2018). Low educational attainment correlates significantly with the risk of unemployment and results in lower earnings, while labor market inactivity, in the long run, increases the risk of social exclusion (European Commission, 2010; OECD, 2010; OECD, 2022; Walker & Walker, 1997). Research evidence confirms a significant impact of low compulsory education outcomes and labor market exclusion of individuals at early working age (Parsons & Bynner, 2002). According to this argumentation, individuals face a high risk of poverty due to the absence of education and training possibilities and inadequate skills (Jennings,

1999). In other words, a higher risk of poverty and social exclusion threatens persons with low educational attainment, scarce work experience and unstable labor market position.

On the other hand, it should be accounted for that education is but one determinant of the probability of social exclusion. Some authors claim that only a small part of the variations in individual earnings and participation in the labor market can be explained by education and that low income and unemployment do not correlate strongly with social exclusion (Darity & Underwood, 2021; Dearden, 1998; Saraceno, 2001). Education and income may correlate since both are embedded in individual abilities.

According to the literature on endogenous growth, the market returns to education can be measured at the level of society at large. Education quality and quantity, used to operationalize the availability of human capital, along with other production factors, determine the per capita national output (Haveman & Wolfe, 2002). Education is positively associated with research and innovation, development and diffusion of technology (Foster & Mark, 1996). Society benefits from technology and innovations (discovery, adaptation and use of new knowledge in industry, medicine, and science).

Non-market benefits involve both individual-level non-market effects as well as spillover effects at the societal level. Only one part of the well-being gains that people obtain from education are reflected in labor market returns. Wolfe and Zuvekas (1995) identify several non-market effects of education, ranging from improved personal health to increased efficiency in making different personal choices. Previous research indicates that life expectancy is strongly associated with the level of education (OECD, 2013). There is also a positive relationship between education and individual health status (Sander, 1995), as well as the health of family members (King & Hill, 1993). Higher levels of education increase the likelihood of finding less stressful jobs and encourage individuals to develop healthy life habits and eat more nutritious food. Individuals with higher levels of education are less dependent on social transfers (Haveman et al., 2001). Previous research confirmed educational levels attained by parents significantly determine a child's educational achievement and cognitive development (Duniform et al., 2001). Schooling also contributes to more efficient consumer activities (Morton et al., 2001), fertility choices, family planning (Owens, 2004).

Lower educational levels are associated with decreasing intensity of citizen participation and lower voter turnout (Parsons & Bynner, 2002). Increased levels of democratization, protection of human rights and political stability are also related to increased education (McMahon, 2000). Low education and consequent labor market exclusion initiate exclusion in other domains – political and social life. Employment is not only the source of earnings but also the space for various social interactions. Along with the lack of interest in politics and lower voter turnout, less educated individuals also have a lower rate of participation in community organizations. Higher education levels are associated with higher levels of generalized trust and membership in community organizations (Costa da et al., 2014; Helliwell & Putnam, 1999). Education levels correlate significantly with the amount of money, effort, and time spent in charitable activities (Hodgkinson & Weitzman, 1998), which may positively affect social cohesion. Higher levels of social cohesion are characteristic of societies where citizens actively participate in civic activities and trust others. On average, adults with higher levels of education report stronger civic engagement in terms of volunteering, voting, interest in politics, and interpersonal trust than those with lower levels of educational attainment (OECD, 2013).

According to McMahon (2000), human welfare depends not only on earnings but also thrives from reducing poverty and crime, clean environment and other non-monetary outcomes that could be linked to education in various ways. Mingat and Tan (1996) list the following social benefits of education: improving social equity, strengthening social cohesion, reducing environmental degradation through the effects of education on fertility and population growth and lowering crime rates. Schooling is associated with reduced criminal activity (Lochner & Moretti, 2001), as educated young people with good prospects of finding a well-paid job are less likely to engage in criminal activities. Higher levels of education lead to lower fertility rates in females and eventual net population growth, especially in less developed countries. This, in turn, is associated with reduced water pollution and environmental protection. Sen and Acharya (1997) point out that policies oriented

towards education have positive effects on poverty reduction and health, especially for the poor. Schooling is related to reduced alienation and social inequalities (Comer, 1988).

Extensive research on both the market-based effects of education and those not covered by market benefits indicates the relevance of education for various social and economic outcomes.

1.2 Study area

Among the Western Balkan economies, Serbia appears to be the example of a country that has failed to improve its performance in the areas of social inclusion and social protection as strongly as compared to its economic growth (Kahlert & Sandu, 2021). In order to enable advances in social progress and achieve sustainable and inclusive growth, strengthening the social protection, labor, and education market system remains a significant challenge for the region's countries. Regarding most of the principles of the European Pillar of Social Rights (European Commission, 2021a), Serbia is performing well below the EU average. In Serbia, at-risk-of-poverty and income inequality indicators are high compared to average EU 27 values. In 2021, the total share of the population exposed to the risk of poverty is 21.2%, while 28.4% face at-risk-of-poverty or social exclusion. The situation is similar in other Western Balkan countries, also being significantly below the EU average. The data are somewhat more favorable for Croatia, where the at-risk-of-poverty rate is 18%, while the at-risk-of-poverty-and-social-exclusion rate mounts up to 20.9%. Among the surrounding countries, Slovenia is the best performer, with an at-risk-of-poverty rate of 12.1% and an at-risk-of-poverty-and-social exclusion rate of 13.3%. The risk of poverty rate among the employed is significantly lower in Croatia (4.9%) and Slovenia (4.8%) than in Western Balkan countries. The at-risk-of-poverty rate among the employed is 9.2%, indicating that some persons cannot cope with financial difficulties despite employment. Children and young people between 18 and 24 years of age face at-risk-of-poverty rates of 20.8% and 27.7%, respectively. The Gini coefficient has been reduced to 33.3, but it remains among the highest in Europe.

In the field of equal opportunities and access to labor market, Serbia performs below average (Arandarenko, 2020). In the last few decades, Serbia has launched several reforms to meet a growing demand for more equitable and higher-quality education. Both primary (mandatory) and secondary education are free, while access to higher education is guaranteed to all under equal conditions. However, despite efforts, the Serbian education system is still faced with the problem of ensuring equity and equality. Education is generally inclusive, although some vulnerable groups (Roma children and children with disabilities) are underrepresented in the education system.

The education system is not providing an equal quality of education to the students compared to the EU countries. Its most recent outcomes are well below the EU average, as reflected in the results from the 2018 OECD PISA assessment (OECD, 2020). In Serbia, the average achievement on the reading literacy scale was 439, compared to 487 in the OECD, with a gap of 48 points. Compared to OECD countries, the competencies of Serbian pupils on the mathematical literacy scale were lower by 41 points (489 compared to 448). Competences of OECD pupils (489) are higher by 49 points on the science literacy scale compared to Serbian pupils (440), which indicates a one-and-a-half year lag behind OECD countries. According to these results, every third student in Serbia did not reach the functional literacy threshold, 38% of students did not reach the basic level of literacy in reading, 40% in mathematics, and 38% in natural sciences. The finding that more than 80% of students from three-year secondary vocational schools (compared to 21–25% in OECD countries) are below that level is considered particularly worrying. Socio-economic status is a strong predictor of performance in various segments of literacy in PISA participating countries, while the variation in mathematical and science literacy scores shows a weak relation. Disadvantaged students in Serbia lag around two years behind their peers from wealthier families in the reading domain of PISA 2018. Socio-economically advantaged students outperformed disadvantaged students in reading by 73 points. In summary, PISA assessments revealed that a significant number of pupils in Serbia complete their education without acquiring the necessary skills. These issues urge the redefining of funding policies and the introduction of changes aimed at enhancing

Tab. 1: Investment in education (2019)

Country	Government expenditure on education, total (% GDP)	Government expenditure on education (% of government expenditure)
Serbia	3.6	8.6
World	4.3	12.6
CE & Baltics	5.1	10.7
EU	5.1	10.4
OECD	5.3	10.9
Middle income countries	4.1	15.2

Source: The World Bank (2020)

the quality of teaching and learning. The inadequately resourced education system (Tab. 1) has limited capacity to provide high-quality and equitable education.

Investment in education as a % of GDP in Serbia (3.6) is below the average for the group of countries with the same income (middle-income countries). It is significantly below the EU average (4.6%), the OECD average (5.0), and Central Europe and the Baltics (5.1). Serbia also lags in government expenditure on education as a % of total government expenditure. The cumulative expenditure per student is USD 24,290 (PPP adjusted) over the lifetime in compulsory education, as opposed to USD 90,000 average in the EU (OECD, 2017). Education in Serbia is also faced with the problem of inadequately supplied material sources – 49.4% of students are reported to have hindered learning outcomes by the lack of textbooks, library and laboratory resources, and ICT equipment, while 16.3% of computers do not have access to internet, with one computer available to 3.3 students (CEB, 2021). These facts put Serbia at a high risk of getting into the low value-added growth trap, hindering its transition to a digital society and building the workforce with skills and competencies for future labour market demands.

2. Research methodology

2.1 Data and variables

In our analysis, we use the annual European Union Statistics on Income and Living Conditions (EU-SILC) as a widely used source of multidimensional microdata in research studies on income, poverty, social exclusion and other living conditions. We utilize the cross-sectional data obtained in Serbia in 2020, based on a nationally representative sample of the population residing in private households within the country. A total of 5,158 private households and 13,855 persons aged 16 and over have participated in the survey. The data obtained at the household level relates to social exclusion and housing conditions, while individual-level data provides information about labor, education, and health conditions. Income and calculation of basic EU-SILC instruments is based on data collected both at personal and household level (European Commission, 2021b).

In the first step, we identify the households exposed to the risk of poverty and social exclusion. Our measure represents the number of individuals living in households that are either at risk of poverty or severely materially deprived (Tab. 2):

i) For the measure of poverty, we use the at-risk-of-poverty rate, which represents the share of individuals who have an equivalized disposable income below the risk-of-poverty threshold, set at 60% of the national median equivalized disposable income (after social transfers).

ii) For measuring social exclusion, we equate being socially excluded with material deprivation, which is manifested in the inability to meet basic needs, having problematic debts or payment arrears. In our case, this is measured by the severe material and social deprivation rate (SMSD): the proportion of the population experiencing an enforced lack of at least 7 out of 13 deprivation items (6 related to the individual and 7 related to the household).

Tab. 2: Individuals at risk of poverty or severe material deprivation in Serbia

Variable		Frequency	Valid (%)
At risk of poverty	Yes	2,835	21.4
	No	10,388	78.6
	Total		100.0
Severely materially deprived	Yes	3,645	27.6
	No	9,578	72.4
	Total		100.0
At risk of poverty or severely materially deprived	At least one	4,732	35.8
	None	8,491	64.2
	Total		100.0

Source: Eurostat EU-SILC (2020)

In the next step, we select a set of individual-level explanatory variables that serve as risk factors of poverty and social exclusion. We address the abundant literature on potential causes and predictors of poverty and social exclusion (Burchardt et al., 2002; Jehoel-Gijsbers & Vrooman, 2007; Levitas, 2006) to identify the social indicators that influence the likelihood of becoming poor or socially excluded. Besides individual-level risk factors (low income, poor health, low education level, unskilled labor, gender, old age), it is documented that poverty and social exclusion can be a consequence of the actions not only of the afflicted persons but also other individuals or corporate actors, government policies or result from more general socio-economic developments (economic recessions, demographic transitions, cultural changes). For this study, we focus on the risk factors that operate on the micro-level of individuals. Our main variable of interest is the level of educational attainment. In addition, we include in the model various sociodemographic, labor market and health-related variables as risk indicators (Tab. 3).

Tab. 3: Variables, definitions and data sources

Variable	Definition	Source
Education	Educational attainment level: the highest ISCED level successfully completed	Eurostat EU-SILC
Health	Self-perceived general health	
Employment	Self-defined main activity status	
Age	Age in completed years at the time of the interview	
Gender	Self-declared personal characteristics	

Source: own

In our analyses, we presume a one-sided causality by estimating to what extent the risk factors increase the probability of poverty and exclusion. The empirical literature, however, implies that the relations between the causes and manifestations of social exclusion can be reciprocal. Based on the available cross-sectional data that we operate with, we do not attempt to estimate the two-way causal effects that are not to be neglected.

2.2 Estimation procedure

We begin by transforming our response variable into a set of observations with two unique values (0, 1), where 1 denotes the occurrence of our expected outcome (individuals at risk of poverty and social exclusion). Next, we fit a regression model that relates our dependent variable to selected predictor variables, both quantitative and categorical. The procedure of choice for modelling dichotomous or binary outcome variables is the probit analysis (Aldrich & Nelson, 1984). In this procedure, the inverse standard normal distribution of the probability is modelled as a linear combination of the predictors. We examine the variables related to sociodemographic, health and labor related characteristics of the respondents to assess their impact on the probability of being in the risk category. The model we fit is:

$$\Pr(\text{at risk} = 1) = \Phi(\beta_0 + \beta_1 \text{education} + \beta_2 \text{health} + \beta_3 \text{employment} + \beta_4 \text{age} + \beta_5 \text{gender}) \quad (1)$$

where: Φ – the standard normal cumulative distribution.

We perform Likelihood ratio tests to test the significance of the coefficients in three different model specifications. Based on the obtained coefficients, we calculate the predicted probability of risk of poverty and social exclusion for different levels of educational attainment of the respondents.

3. Results and discussion

In this section, we present the results of a fitted probit regression model, where we test the impact of education and selected demographic, health-related and labor market variables on the risk of poverty and social exclusion. Three different model specifications are included: (1) with the risk of poverty as a dependent variable; (2) with severe material deprivation as a dependent variable; and (3) the specification that calculates the predicted probability of being both at risk of poverty and severely materially deprived (at least one of the risks). Based on the model fitting information that compares a model that includes the specified predictor variables to the one that simply fits an intercept to predict the outcome variable, likelihood ratio chi-square tests confirm that at least one of the predictors' regression coefficients is not equal to zero in all models. According to the chi-square statistics, all the models are significant at the 0.01 level. The response variables predicted by the model are binary (at risk/not at risk of poverty and social exclusion), so the models predict the probability of individuals being at risk given the values of the predictors in the model.

The results do not differ largely across these three specifications, indicating that education plays an important role in predicting the risk of poverty and social exclusion, along with several individual-specific factors. Tab. 4 summarizes the results of three different model specifications, reporting the estimated coefficients along with corresponding standard errors in parentheses.

We hypothesized a direct effect of educational attainment level on reducing the risk of poverty and social exclusion. The regression coefficients in each model indicate that an increase in the educational attainment level significantly decreases the predicted probability of poverty and exclusion. Regression coefficients show the expected direction and are statistically significant ($p < 0.01$). Educational attainment level plays a significant role both in reducing the risk of poverty and material deprivation. The variable keeps its significance in the model that predicts the probability of either poverty or deprivation. Holding all predictors in the model constant at their means or median values (except gender and activity status), a one-level increase in educational attainment affects the probability of poverty and social exclusion in the following manner (Tab. 5).

Our analysis highlights the importance of education for alleviating the risks of exclusion and poverty. As indicated by the probabilities presented in the table, the decrease in the probability of poverty and social exclusion attributed to a one-level increase in educational attainment amounts up to 7.96% (for unemployed women with only primary education). The highest gains from schooling are materialized for the categories of respondents that are not active in the labor market and those with the lowest levels of educational attainment, these categories are also most vulnerable to the risk of poverty and exclusion. However, it appears that higher educational achievements reduce the risk of poverty and social exclusion, irrespective of the starting position or the activity status of the respondents. In other words, it always pays off to have a better education,

Tab. 4: Probit regression estimates

Parameters	At risk of poverty (1)	Severely deprived (2)	At risk of poverty or severely deprived (3)
Intercept	0.066	−0.421***	0.112*
	(0.0700)	(0.0686)	(0.0641)
Education	−0.002***	−0.003***	−0.002***
	(0.0001)	(0.0001)	(0.0001)
Health	0.237***	0.316***	0.290***
	(0.0170)	(0.0166)	(0.0161)
Employment	−0.726***	−0.629***	−0.704***
	(0.0286)	(0.0289)	(0.0276)
Age	−0.003***	0.006***	0.004***
	(0.0009)	(0.0009)	(0.0009)
Gender	−0.130***	−0.046*	−0.076***
	(0.0264)	(0.0258)	(0.0243)
Observations	13,274	13,274	13,274
Chi-square (df)	1,740.623 (5)	2,830.567 (5)	2,736.323 (5)
Sig.	0.000	0.000	0.000

Note: SE in parenthesis; ***significant at 0.01 level; *significant at 0.1 level.

Source: own (based on Eurostat (EU-SILC))

regardless of the individuals' labor market position or the highest level of education completed.

The results are in line with previous research studies that marked lower educated individuals (no education, primary schools) at higher risk of social exclusion (Chung et al. 2019; van Bergen et al. 2014). Educational underachievement acts as a factor that marginalizes individuals

Tab. 5: Predicted probabilities of being at risk of poverty and social exclusion (%)

ISCED level completed	Employment (inactive)		Employment (active)	
	Men	Women	Men	Women
Less than primary	65.93	63.11	38.46	35.59
Primary	58.34	55.36	31.09	28.46
Lower secondary	50.42	47.39	24.40	22.08
Upper secondary	42.49	39.54	18.58	16.62
Post secondary non-tertiary	34.85	32.08	13.71	12.11
Short cycle tertiary	27.28	25.29	9.79	8.54
Bachelor or equivalent	21.50	19.34	6.77	5.83
Master or equivalent	16.12	14.34	4.52	3.84
Doctorate or equivalent	11.71	10.29	2.92	2.45

Source: own (based on Eurostat (EU-SILC))

by hindering their opportunities at the labor market and limiting their ability to participate in the decision-making processes in society (Gomez-Torres et al., 2019). Some studies emphasize the dominating indirect effects of poor education and mechanisms of their influence on social exclusion – via low income, poor health, poor digital skills or poor command of language in the case of migrants and ethnic minorities (Jehoel-Gijsbers & Vrooman, 2007). Their analysis of 860 Dutch households has revealed the significance of education and ethnic origin as key background variables for explaining the process of social exclusion. Research from the Western Balkans also confirms that individual characteristics, such as education, account for the differences in social well-being. In a study of labour market challenges in Western Balkan countries (Bartlett et al. 2020), low educational levels of young people are proved to act as barriers to their employment. Strong correlations between poverty and poor education (primary or less) have been recorded throughout Western Balkans (Matković, 2017). In a household-level analysis of subjective perceptions of poverty in the countries of emerging Europe, Koczan (2006) finds that individuals with higher educational attainment are less likely to subjectively grade themselves as poor, have higher expectations of future income and report higher amounts of minimum income necessary for their subjective well-being.

Our analysis also confirms the importance of multiple factors that affect the risk of poverty and social exclusion. The impact of education is assumed to work to a large extent through the labor market, as higher education enables employment (Klein, 2015). Poor education increases the probability of individuals' low labor market position (worse working conditions, low wages for the employed, unstable employment in the informal sector, seasonal jobs or unemployment). In our model, we have included the variable that reflects individuals' self-defined activity status to assess the effects of being unemployed, unable to work due to health reasons or disabilities or generally inactive on the risk of poverty and social exclusion. As expected, this variable significantly predicts the probability of being at risk of poverty or severe material deprivation. The negative sign of the employment status coefficients indicates that belonging to a non-active category is associated with a significantly higher risk of poverty and exclusion. Employment not only provides financial resources, but also access to other social resources (Waddell & Burton, 2006). Not having paid work, being on social assistance or disability benefit are considered to be the basic risk factors of poverty and social exclusion (Walsh et al., 2017), although there is a possibility that some jobs are more socially excluding than being jobless (Atkinson, 1998). A specificity of the Western Balkan countries is that a large share of unemployed live in households where the income is shared between household members, so the largest risk of poverty and exclusion is among the unemployed living in households with low work intensity (Matković, 2006). In addition, not any kind of employment is significant for reducing the risks of poverty, but better paid jobs in the formal sector of the economy.

Self-perceived health status enters the model with the expected sign, indicating that poor health increases the probability of being in the risk category. These findings fit general patterns in terms of health being considered a rather robust determinant of social well-being in previous research (Sacker et al., 2017). In addition, poor educational achievement along with poor self-perceived health are found to be significant risks of unemployment (Bell & Marmot, 2017).

In summary, estimation results underline the important role of individual level characteristics as fundamental risk determinants. A somewhat unexpected finding is that women in our model do not appear to be at higher risk of poverty or social exclusion. This result contradicts the most common results of previous research that finds women to be at higher risk of social exclusion (Becker & Boreham, 2009), especially in the areas of material resources, access to information, civic participation and cultural activities (Kneale, 2012). The impact of age differs across our model specifications, indicating that age increases the probability of severe material deprivation and the combined risk of poverty and deprivation, while older age appears to go in hand with a lower risk of poverty itself. A recent study (Nilsen et al., 2022) indicates that educational attainment acts as a factor of exclusion at an older age, indirectly through non-employment and health problems, and directly causing exclusion from social and civic activities.

Conclusions

This study examined the relationship between educational attainment levels and the social well-being of individuals, using cross-section data from a representative sample of the population in Serbia. The results indicate that several fundamental determinants shape poverty and social exclusion, yet underlining the importance of education as an important risk factor of poverty and social exclusion.

The research question of our study addressed to what extent the achieved levels of education can predict the risk of poverty and social exclusion. Our findings indicate significant influence of educational attainment, along with other risk factors that can be directly or indirectly affected by education (labor market activity, health status). It could be argued that educational underachievement increases the risk of exclusion in several life domains. We found that increasing levels of education significantly decreases the probability of both poverty and severe material deprivation, affecting mostly the individuals with the lowest levels of educational attainment and those inactive in the labor market. As expected, individuals at the highest risk of poverty and social exclusion are those with less than primary education, inactive in the labor market, with men being exposed to a slightly higher risk than women.

Our findings highlight the importance of optimizing investment in various levels of education. From the policy perspective, equally challenging endeavors seem to be increasing the share of budget expenditures for education and addressing the identified deficiencies of the education system in terms of strengthening quality. It is clear from the sampled data that the poor have low education levels, which can be related to the problem of universal access to primary education. In Serbia, there is a guaranteed right to education, the rate of early school leavers is low (decreased to 5.6% in 2020; EC, 2021), but an intervention is needed regarding the underrepresentation of certain vulnerable groups in education. Efforts aimed at increasing the participation of disadvantaged students at all levels of education, especially primary and secondary, could effectively build an inclusive and equitable education system. Increasing the participation of adults in lifelong learning, especially low-skilled individuals, which is below the EU standards, could contribute to reducing the risks of poverty and social exclusion.

As our study indicates higher returns to education at secondary levels in terms of reducing poverty and social exclusion, expanding investment in secondary education would be a reasonable policy reaction. Investment in higher levels of education should account for the increasing demand for skilled workers and be adjusted to the labour market requirements. In Serbia, secondary education is not mandatory, which might be a cause of a relatively large percentage of the population without completed secondary education (around 16%; Arandarenko, 2020). Although the education levels of the population in Serbia have been increasing in recent years, the latest PISA assessments raise concerns about the quality of education, urging for policies that would assure high-quality teaching and improve teaching practices.

Highlighting the relevance of various fundamental determinants of poverty and social exclusion besides education, our findings indicate the need for an approach to integrate different policy areas and target a wide range of risk factors for poverty and social exclusion.

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The influence of the COVID-19 pandemic on managerial functions: Theory verified by Delphi method

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Abstract: *The aim of the article is to analyse the performance of managerial functions in the context of the COVID-19 pandemic. The first part of the article focuses on a systematic literature review (SLR) aimed at identifying the most frequently researched managerial functions in the context of changes due to the pandemic and the difficulties in performing these functions. A total of 211 articles from the Web of Science database were analysed, 18 of which were relevant to the present research. Based on the SLR conducted, two research questions were identified and answered by conducting a three-round Delphi survey among the experts interviewed (a total of 23 company managers). The results show that during the COVID-19 pandemic, the managerial function of planning has the highest importance and was performed the most often, followed by the function of leading. The managers gave minor importance to the organising function, which was statistically confirmed by Friedmann ANOVA followed by post hoc analysis – the Bonferroni-Dunn test. The results also confirmed a satisfactory level of expert agreement on the data obtained (Kendall W ~ 0.7–0.84), confirming the relevance of the findings. Also, several internal barriers that affected the work of managers were identified. The results are somewhat unusual, as most of the constraints faced by managers were imposed by the external environment, such as government regulations or sanitary measures. This discrepancy suggests that companies should emphasise improving their crisis management in the future. The results obtained thus provide the basis for further research in the area analysed. At the same time, it is possible to move away from the COVID-19 situation and transform the issue into managerial management in crises.*

Keywords: *Systematic literature review, crisis management, planning, internal barriers.*

JEL Classification: *M12, M54.*

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Introduction

Until 2019, the global pandemic was seen as something that could not happen in the modern world. However, the disease called COVID-19 showed the world the opposite when, on March 11, 2020, the World Health Organization declared a global pandemic. The situation led to several restrictions in various areas, which all had the common goal: limit the spread of the disease. As the disease spread among people, the governments usually ordered/recommended people to stay at

home, which led to the necessity of people working or studying remotely (whenever possible). Due to these measures, as well as due to the sickness itself, many things in many areas of life had changed, which resulted in "millions of deaths, job losses, and a multitrillion dollar decline in economic output" (Panwar et al., 2022, p. 5).

The extent of the impact of this situation on businesses differed by the sector in which they operated. The more significant impact was on the sectors that can only operate with the presence of people, e.g., tourism (Utkarsh & Sigala, 2021), culture (Kraus et al., 2020), and sports (Ratten, 2020). Business in this sector was considerably limited in many European countries (at least at the beginning of the pandemic). A minor impact was on the sectors that were able to function but had to face problems, e.g., regarding the shortage of employees (Messabia et al., 2022), fewer supplies (due to the collapse of supply chains; Chatterjee & Chaudhuri, 2022), specifics of working from the office as well as working from home (Manko, 2021) or the necessity to sell online (Schleper et al., 2021; Singh & Singh, 2022).

All the problems that arose in businesses during the COVID-19 era had to be dealt with by people, especially by managers (for this paper, there will be no difference between business owners and managers, both groups will be called managers). Managers are the people responsible for achieving the organisation's goals. Usually, to do that, they use several managerial functions (most often planning, organising, leading, and controlling (Jones & George, 2017)). Due to the COVID-19 situation, some skills, abilities, and people's knowledge changed (Hartmann & Lussier, 2020). For example, many people had to learn how to face rapid changes (Zaoui et al., 2021), how to use technologies that allowed them to work from home (Hartmann & Lussier, 2020), or how to deal with a higher level of stress they were facing (Koch & Schermuly, 2021). Thus, it can be assumed that these changes also affected managers and the performance of their functions.

Since the correct performance of these functions is crucial to maintaining the business's overall performance, it is necessary to study the changes that can influence them. Significantly, the changes that occurred due to such events as the COVID-19 pandemic are essential to analyse because this type of event represents a global problem whose solution can give instructions on how to solve similar (even less significant) problems in the future. Thus, the aim of this paper is to analyse the performing of managerial functions in the context of the COVID-19 pandemic. In more detail, this research aims to empirically verify the changes and possible barriers to the performance of managerial functions revealed by systematic literature review and to identify additional ones (by using the Delphi method).

The authors of this research realise that managers who managed employees working from the usual workplace faced different challenges than managers who managed people working from home. Both groups dealt with restrictions, shortage of people or other resources, or changes in buyers' behaviour (transition to online shopping). The difference is that managers from the first group (usual workplace) had to change the processes to make sure people would not meet each other unnecessarily, often dealing with a more significant shortage of employees (some employees

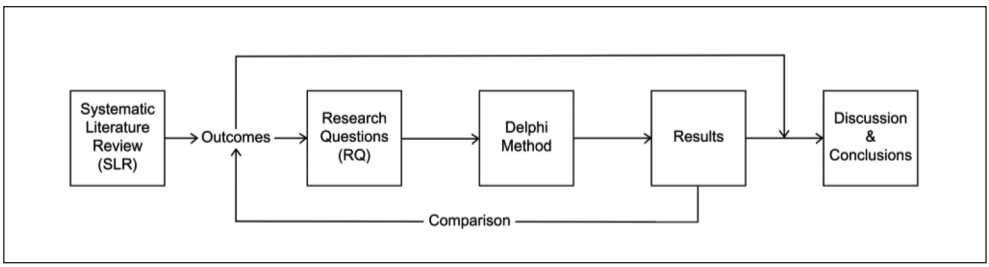

Fig. 1: Flowchart of the research framework

Source: own

positively tested on COVID-19 were able to work, however, they could not be present in the workplace due the restrictions). However, in our opinion, the managers from the second group (work from home) deserve special attention because they had to deal with the quick increase of remote working and its consequences (e.g., providing necessary IT equipment, and appropriate training) with more probability to affect managerial functions (e.g., organising and controlling of the work done) that are worth more detailed research. Thus, it was decided that this empirical research focuses only on the managers that managed people who worked predominantly from home).

The research structure follows the procedure framework shown in Fig. 1. The changes in the performance of managerial functions revealed in the existing literature are introduced by a systematic literature review (SLR), and the resulting research questions are presented. A Delphi survey is carried out to answer them. The survey results are then retrospectively compared with the results of the SLR framework. The research is concluded with a discussion and conclusions.

1. Theoretical background

1.1 Managerial functions

Firstly, it is necessary to define the managerial functions, which differ from author to author. Contemporary specialised books use many functions, such as planning, organising, commanding, coordinating, controlling, leading, decision making, influencing, motivating, staffing, and communicating (McNamara, 2009). However, the four functions (planning, organising, leading and controlling) are the most often used. They can be found in specialised books (Bateman & Konopaske, 2022; Certo & Certo, 2019; Jones & George, 2017; Robbins & Coulter, 2021). Thus, in this paper, managerial functions will be seen according to these authors.

Planning can be defined as "specifying the goals to be achieved and deciding in advance the appropriate actions needed to achieve those goals" (Bateman & Konopaske, 2022, p. 11). The second function is about "arranging and structuring work to accomplish organisational goals" (Robbins & Coulter, 2021, p. 307). "The process of guiding the activities of organisation members in appropriate directions" (Certo & Certo, 2019, p. 336) is the definition of leading (sometimes also called "influencing)". And the aim of controlling is "to evaluate how well an organisation has achieved its goals and to take any corrective actions needed to maintain or improve performance" (Jones & George, 2017, p. 10).

1.2 Delphi method

The Delphi method is used to analyse the selected issue to extend the findings from the systematic literature review with additional empirical data. This research methodology finds application in various domains, such as problem identification, solution finding, and discerning distinctions among multiple reference groups (Delbecq et al., 1975). The schematics of the individual phases of the Delphi method are shown in Fig. 2.

The Delphi method is a multi-round questioning design (most typically three rounds; e.g., Crucke & Decramer, 2016; Green, 2014) with controlled feedback (Dalkey & Helmer, 1962; Grime & Wright, 2016). The respondents are selected experts involved in the survey and chosen based on predefined criteria. The above ensures the presence of respondents with appropriate experience or expertise on the issue being researched (Ferreira et al., 2014; Habibi et al., 2014). To achieve higher reliability and objectivity in the research process, it is essential to guarantee sufficient heterogeneity (diversity) in the structure of the panel of experts selected (Okoli & Pawlowski, 2004). The recommended number of experts varies; e.g., Grime and Wright (2016) and Landeta (2006) suggest a number between 5 and 30, Gordon (1994) suggests 15–35 people and Witkin and Altschuld (1996) suggest below 50 people.

Concentrating on the rate of return, which may be affected by the vice-round system, where individual experts leave for various reasons, a rate of 50–80% can be considered, with 35–75% reported by Gordon (1994), and similarly 40–77% by Egerová and Mužík (2010).

Delphi can be classified as a qualitative research method. However, the statistical evaluation of the method is supplemented with quantitative elements. For the implementation and evaluation of the survey in this study, the approach used was that of García-Uceda et al. (2017), who work with descriptive statistics in the framework of the inter-round evaluation, and with Kendall's coefficient of concordance for the latter rounds (the 3rd or more; Egerová & Mužík, 2010).

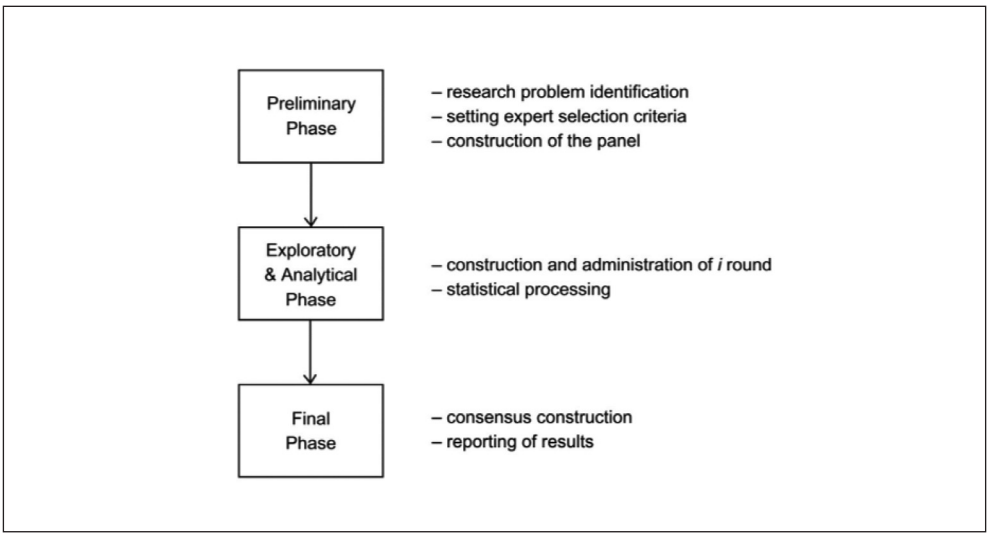

Fig. 2: Design of Delphi method

Source: own (based on Montes Hincapié et al., 2017)

1.3 Identified changes in the performance of managerial functions – Systematic literature review

To identify changes in the performance of managerial functions due to the COVID-19 situation, a systematic literature review was done on the Web of Science database in January 2023. The research questions focused on: i) identifying the most often researched managerial functions in the context of changes due to COVID-19; and ii) the difficulties of performing these functions. To do this, the keywords "covid," "change," and "management" were searched for in the "Management" category (English language publications with no restriction regarding the year of publication). Although 211 articles were found initially, only 18 papers were relevant to answer the research questions.

The resulting papers are shown in Tab. 1 and categorised according to the managerial function they were concerned with (the last column of Tab. 1). Within this category, publications are sorted according to the year of publication. Tab. 1 details the methodological approach, the type of management, the geographical focus, and the sample for each publication.

As to the methodological approach, eight papers are based on questionnaires, six on interviews, two are based on case studies, one is theoretical, and one is a literature review. In most papers (five), the type of studied management is not specified. In four cases, the paper is based on business owners' opinions, and the rest is focused, e.g., on public sector managers, HR managers, and project managers. As to geographical focus, studies about European management predominate.

At first, it was revealed that no publication that aimed to analyse the changes in the performance of managerial functions directly exists in WoS. At this point, the search for this type of publication was expanded to all sources, and finally, one paper was found in Google Scholar (thus, it will not be part of the following SLR, but it cannot be omitted). Miklosevic et al. (2022) interviewed operation managers in 35 Croatian companies in 2022 to discover the problems managers faced in performing their managerial functions. They found that managers had to deal with changes related to planning and organising functions (both because of the absence of workers). On the other hand, the controlling function was the least affected function (almost no changes).

The 18 papers included in SLR mainly mention changes in the performance of some

Tab. 1: Overview of the papers

Citation	Methodological approach	Focus on management type	Geographical focus	Sample	Managerial function
(Soluk, 2022)	Questionnaire	Family firms' owners	Germany	112 family firms' owners	Planning
(Cervinka & Novak, 2022)	Case study	Managers	Czechia	8 managers, leaders, and workers in the SMEs	Leading
(Yue & Walden, 2022)	Questionnaire	Managers	USA	414 full-time US employees	
(Ayoko et al., 2021)	Literature review	Managers	–	–	
(Koch & Schermuly, 2021)	Questionnaire	Agile project management	Germany and USA	168 German and 292 American employees in project-related firms	
(Racaite-Samusiene et al., 2021)	Interview	Public sector managers	Lithuania	6 top and middle-level managers of municipal administration	
(Schleper et al., 2021)	Case study	Operations and supply chain management	UK	Management scholars and Marks & Spencer's head of procurement	
(Amis & Janz, 2020)	Conceptual/ theoretical	Managers	–	–	
(Messabia et al., 2022)	Interview	Owners of restaurants	Canada	6 restaurant owners	Organising
(Almazrouei & Zacca, 2022)	Questionnaire	Public sector managers	Austria	55 public sector managers	Leading, organizing, controlling
(Gonçalves et al., 2021)	Questionnaire	HR management	Portugal	136 HR managers	Leading, organising
(Rashid & Ratten, 2021)	Interview	Entrepreneurs	Pakistan	20 entrepreneurs	Leading, organising
(Manko, 2021)	Questionnaire	Managers	Various	158 managers (from various types of organisations)	Planning, leading
(Tomcikova et al., 2021)	Questionnaire	HR management	Slovakia	137 HR managers	Planning, organizing
(Zaoui et al., 2021)	Questionnaire	Strategic innovation management	Marocco	57 managers	Planning, leading, organizing
(Dănilă & Adam, 2020)	Interview	Project management	Romania	5 project managers	Planning, leading, organising
(Hartmann & Lussier, 2020)	Interview	Sales manager	North America or global	8 managers (various types)	Organising, leading
(Kraus et al., 2020)	Interview	Family firms' owners	Austria, Germany, Italy, Lichtenstein, Switzerland	27 top managers or responsible areas managers of family businesses	Leading, organising

Source: own

managerial functions while their aim is focused on different issues. In Tab. 1, the papers are sorted into categories according to the managerial function they deal with. If they are dealing with more than one, it is clearly stated.

The most often mentioned function that changed due to COVID was leading (altogether in 15 papers). In these 15 papers, motivation was the most often mentioned change regarding leading function (7 times). It was identified that for managers during the COVID-19 era, having the ability to motivate employees was necessary (Rashid & Ratten, 2021), as well as having emotional intelligence and empathic capabilities (Schleper et al., 2021). It is because COVID-19 caused a decrease in employees' motivation, loss of morale, and resignation (Cervinka & Novak, 2022) as well as emotional exhaustion due to the accumulation of unfinished tasks (Koch & Schermuly, 2021) and the inability of employees to keep on task (Manko, 2021). Also, it was revealed that some managers could inspire, influence, motivate, and encourage their followers (Racaite-Samusiene et al., 2021) or take care of employees' physical and mental health (Hartmann & Lussier, 2020).

Secondly, communication during COVID-19 has changed. It was accelerated (Cervinka & Novak, 2022) and ongoing on several platforms, often online, such as WhatsApp or Facebook (Kraus et al., 2020; Rashid & Ratten, 2021). It was necessary to allow employees to have all the information they needed (Manko, 2021) and communicate transparently (Yue & Walden, 2022), to get used to the change.

The last identified common topic regarding leading was the challenge of leading people working remotely. For managers, it was necessary to have skills in working virtually (Ayoko et al., 2021) and also it was necessary to immediately provide training in these skills to the employees (Almazrouei & Zacca, 2022; Gonçalves et al., 2021; Hartmann & Lussier, 2020).

The COVID-19 situation influenced the leading of strategic innovation management initiatives (Zaoui et al., 2021) and of people working on projects (Dănilă & Adam, 2020). Also, more attention should be paid to employees (people-centred approach) as a response to the COVID-19 situation (Amis & Janz, 2020).

As to organising, the function was mentioned in 9 papers. They include several topics such as coping with the immediate necessity to work from home, together with having adjusted the work system and providing necessary technology (Almazrouei & Zacca, 2022; Kraus et al., 2020) as well as the related change of the work organisations (Gonçalves et al., 2021). Also, it was identified that organisations and their management had to adapt to buy or sell online (Rashid & Ratten, 2021) or to deal with the regulations of constant closures and openings (Messabia et al., 2022) and thus constantly rescheduling tasks (Hartmann & Lussier, 2020). Regarding employees, managers had to deal with their shortage (Messabia et al., 2022), with the changes in the process of their selection and recruitment (Gonçalves et al., 2021) or even with the fact that no employees were hired during the COVID-19 era at all (Tomcikova et al., 2021). Also, the same as with the leading, the COVID-19 situation influenced the organising of strategic innovation management initiatives (Zaoui et al., 2021), and of people working on the projects (Dănilă & Adam, 2020).

Regarding planning, five papers were found that mentioned this function. The lesson learned from this situation is that organisations should have prepared plans for these types of situations (Tomcikova et al., 2021) because the planning was problematic for some organisations at that moment (Manko, 2021) or to have a strategy on how to finish on time (Dănilă & Adam, 2020). Also, it was identified that long-term planning was not possible anymore, and organisations had to adapt to short-term planning (Soluk, 2022). The same as with leading and organising, the COVID-19 situation influenced the planning of strategic innovation management initiatives (Zaoui et al., 2021).

As to controlling function, this was surprisingly mentioned only once in the paper written by (Almazrouei & Zacca, 2022), who pointed out that the performance and KPIs of organisations had lower values and it was necessary for managers to adapt their style of management to monitor their employees remotely.

To summarise, the most often mentioned topics in current literature about the performance of managerial functions during the COVID-19 are motivation, communication, the necessity to provide training for gaining specific abilities and skills (regarding remote working), as well as providing the necessary technology for employees, the necessity to change the processes (due to, e.g., online selling, and remote work), to react quickly to immediate changes (closure and re-openings, rearranging scheduled tasks),

to deal with the shortage of employees, to adapt to short-time planning, and to monitor the work of employees. In light of these identified changes, the first research question was stated.

RQ1: What changes in the performance of managerial functions due to the COVID-19 situation identified in literature can be verified empirically?

Secondly, while processing the SLR, many difficulties in performing managerial functions in the COVID-19 era were revealed. Many organisations had to face financial difficulties (Cervinka & Novak, 2022; Messabia et al., 2022) and the need to lay off employees (Rashid & Ratten, 2021). Managers had to deal with a more significant amount of work (Racaite-Samusiene et al., 2021; Rashid & Ratten, 2021), faced problems regarding working, leading and monitoring employees remotely (Almazrouei & Zacca, 2022), problems with communication or obtaining information (Dănilă & Adam, 2020; Kraus et al., 2020; Manko, 2021), which altogether resulted in a lot of pressure and stress (Cervinka & Novak, 2022; Messabia et al., 2022; Schleper et al., 2021; Soluk, 2022). Thus, the second research question was stated in light of these identified difficulties.

RQ2: What difficulties and barriers in the performance of managerial functions due to the COVID-19 situation identified in literature can also be observed empirically?

2. Research methodology

The investigation took place from March to May 2023. During this period, the research problem was defined, the criteria for selecting experts were defined, the questionnaire was piloted, and the three-round survey was conducted with controlled feedback. The research aimed to identify the main managerial activities (related to managerial functions) most frequently performed by managers during the current counter-epidemiological measures.

The criteria for the selection of appropriate experts were as follows: i) an expert is a person who works in a managerial position and has worked in that position before 2020 (before the COVID-19 pandemic); ii) an expert is a person who has at least five subordinate employees (or the number of employees in the department they manage); and iii) an expert represents, from a management position, an organisation whose staff have carried out their work in a combined way – both in the workplace and from home – as part of the epidemiological response. The proportion of remote working was at least 50%.

Tab. 2 provides more detailed characteristics of the companies represented by experts (16)

Tab. 2: Characteristics of represented companies

	Category	Value	Percentage (%)
Total number of employees	<9	3	19
	10–49	3	19
	50–249	5	30
	250–499	3	19
	500+	2	13
Number of direct subordinates	5–9	6	38
	10–25	8	50
	26–50	1	6
	51–250	1	6
	251+	0	0
Levels of manager positions	Top	5	31
	Middle	7	44
	Operative	4	25

Source: own

who participated in all three survey rounds. The data shows that the distribution by size of organisation (in terms of number of employees) is distributed evenly, with a slightly higher representation of medium-sized enterprises. The number of direct subordinates most often ranged 5–25 (5 was a requirement for participation in the survey), corresponding to the most common level of effective management of a group of people. Similarly, the distribution of manager levels is even with a preponderance of mid-level managers.

The qualitative method of coding and subsequent data synthesis was used to evaluate the responses of the first round. The synthesis of the responses was used to unify the opinions and perspectives of each expert. It resulted in the set of the most often mentioned activities, which were subsequently divided into categories according to managerial functions. By coincidence, there was a symmetrical filling of each managerial function with five activities. Also, the four groups of managerial functions (according to the values assigned for each activity) can be compared, and their relationship can be analysed. In the second round, the experts rated the importance of these activities resulting from the first round. The 5-item version of the Likert scale, the most widely used scale (Freese et al., 2011), was used for the rating. The value 5 meant the highest level of agreement and the value one the lowest (thus, the value five meant that the expert "totally agreed that he/she performed the activity and thus it was important during the COVID pandemic"). Cronbach's alpha is used to measure the internal consistency/reliability of the questionnaire, ensuring that the items consistently measure the same construct.

Based on the above, a multi-sample Friedman test – non-parametric ANOVA (Q statistic) was calculated for comparison according to the relationship:

$$Q = \frac{12}{n \times K(K+1)} \sum_{k=1}^{K} R_k^2 - 3n(K+1) \qquad (1)$$

where: $R_k = \sum R_{ik}\ n\ i = 1$ – sum of group ranking; K – number of compared groups; n – number of monitored objects.

The non-parametric test was chosen concerning the results of the Shapiro-Wilk test, which indicated a significant deviation of the data from normality $p < 0.001$. The observed effect size Kolmogorov-Smirnov – D is large (0.1991–0.2343). This indicates that the magnitude of the difference between the sample distribution and the normal distribution is significant.

In case of rejection of the hypothesis of concordance (Friedman test), a subsequent post hoc analysis, specifically the Bonferroni-Dunn test, is needed. IBM SPSS Statistics software is used to compute the post-hoc analyses, which performs Dunn's paired post-hoc tests in the first step. Then, the Bonferroni correction of multiple testing is applied by the software to obtain an adjusted *p*-value (Pereira et al., 2015).

The purpose of the third round of the Delphi survey is to determine the level of agreement among the participating experts. The experts indicated their agreement or non-agreement with the ranking of activities resulting from the second round. By this evaluation, the final ranking of the five activities within each function was determined. The tightness of the rating relationship (agreement) of the experts was measured for each managerial function separately using the non-parametric Kendall's coefficient of agreement (Kendall's W) according to:

$$W = \frac{\sum_{i=1}^{k} R_i^2 - \frac{(\sum_{i=1}^{k} R_i)^2}{k}}{\frac{1}{12} m^2 \times (k^3 - k)} \qquad (2)$$

where: R_{ij} – evaluation by evaluator j for subject i; $R_i = \sum R_{ij}\ m\ j = 1$; k – number of evaluated factors; m – number of evaluators.

The *RQ2* was answered by additional questions that were part of the first round of Delphi. These questions were evaluated by using coding and subsequent categorisation. After receiving the results, the answers were categorised according to the enterprise environment and were made by the authors.

3. Research results

The first survey round was conducted in April 2023 and aimed to obtain a wide range of responses.

A total of 23 selected experts were contacted, with 19 responses (83% return rate), providing 29 different answers. In addition, one expert was eliminated due to non-compliance (more than 50% of the working hours were worked remotely by employees). In total,

20 individual responses (activities) were obtained, and the corresponding managerial functions (planning, organising, leading, and controlling) were assigned to the resulting activities by the research authors. The individual activities and their assignment of managerial functions can be seen in the results of the second round of the survey (Tab. 3).

The second round of the Delphi survey was conducted in May 2023, where respondents (18) rated the importance of the performance of each managerial activity grouped by managerial functions. A total of 16 valid responses were obtained, with an overall return rate of 69.5%. The instrument's reliability was verified by the internal consistency of the items at an acceptable Cronbach's alpha of ~0.78 (Tavakol & Dennick, 2011). The results of the evaluation are shown in Tab. 3. The results indicate that experts gave the highest values (based on mean and median) to activities within the category of planning and leading, with the highest-rated activity being "Setting goals

Tab. 3: Results of the second round – Delphi method

Activities	Managerial function	Mean	Median	Mean	IQR*
Setting goals and tasks for remote work	Planning	4.437	4.0	3.712	1
Changes in financial planning		3.875			
Changes in marketing planning		3.625			
Increased demands on order planning (including international)		3.500			
Selection and allocation of online platforms and infrastructure		3.130			
Delegating tasks	Organising	3.560	3.0	3.100	2
Organising employee coverage		3.375			
Reorganisation and creation of new processes/ activities		3.187			
Creating new structures and teams		2.940			
Ensuring sufficient access to technologies, and tools + training		2.437			
Caring for the mental health of employees	Leading	4.125	4.0	3.662	2
Coordination of workplace communication, including keeping employees informed of updates		3.937			
Flexible working hours (adjustment or implementation)		3.562			
New ways of motivation and benefits		3.440			
Increased demands on operational management		3.250			
Increase in feedback provided – due to limited physical contact	Controlling	3.875	3.5	3.475	1
Regular monitoring of processes and outputs		3.750			
Control of compliance with standards and regulations		3.500			
Random checks of completed work		3.250			
Implementation of measures for proactive risk management		3.000			

Note: *Interquartile range.

Source: own

and tasks for remote work" (4.437). On the other hand, the activity "Ensuring sufficient access to technologies and tools + training" (category of organizing) is the lowest-rated activity with a mean of 2.437.

Next, the Friedman test was performed, and Tab. 4 shows that the null statistical hypothesis of agreement is rejected at a *p*-value of ~0.0011.

Considering the rejection (p-value < 0.05), the data are subjected to post hoc analysis – the Bonferroni-Dunn test (Tab. 5).

From the post hoc analysis results, it is possible to identify significant differences in expert ratings only between the managerial function of organizing and the functions of leading and planning (adjusted *p*-value). No significant differences were found between other managerial

Tab. 4: Friedman's ANOVA

Variable	Average rank	Sum of ranks	Mean	Std. dev.
Planning	2.66875	213.50	3.66250	1.030469
Organising	2.71875	217.50	3.71250	0.798634
Leading	2.06250	165.00	3.10000	0.850912
Controlling	2.55000	204.00	3.47500	1.005995

Note: Friedman ANOVA; ANOVA Chi Sqr. (N = 80, df = 3) = 16.06347; p = 0.001100.

Source: own (processing using SW Statistica, 2023)

Tab. 5: Post hoc analysis (Dunn-Bonferroni test) – Pairwise comparisons

Sample 1 – Sample 2	Test statistic	Std. error	Std. test statistic	*p*-value	Adj. *p*-value
Organising-Controlling	−0.488	0.204	−2.388	0.017	0.102
Organising-Leading	0.606	0.204	2.970	0.003	0.018
Organising-Planning	0.656	0.204	3.215	0.001	0.008
Controlling-Leading	0.119	0.204	0.582	0.561	1.000
Controlling-Planning	0.169	0.204	0.827	0.408	1.000
Leading-Planning	−0.050	0.204	−0.245	0.806	1.000

Note: Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-side tests) are displayed. The significance level is 0.050. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Source: own (using IBM SPSS Statistics, 2023)

functions. The results indicate that activities related to planning, leading, and controlling are similarly rated (in terms of their performance and importance) by experts. It is the logical consequence of the fact that the experts rated organising as the function with the lowest rating of its performance and importance during the valid epidemiological measures (Tab. 5).

The third (final) round of the research took place at the end of May 2023 and aimed to assess the overall ranking in the different areas of managerial functions. Of 23 initial experts, 15 actively participated in this round, indicating an overall return rate of 65%, an above-average expected return rate (Egerová & Mužík, 2010; Gordon, 1994).

Changes in ranking compared to the second round (Tab. 6) occurred only between activities 2 and 3 in the organising function and between activities 4 and 5 in the controlling function. All values correspond to Kendall's W > 0.7, which, according to Habibi et al. (2014), indicates

a strong consensus among experts and enhances the relevance of the data obtained.

3.1 Barriers and difficulties of the COVID-19 era

The following section of the research focused on identifying barriers (*RQ2*) that influenced the performance of management activities/functions. The coding-adjusted identified barriers are shown in Tab. 7. The individual barriers were further categorised according to the distribution of the enterprise environment. The data show that most barriers come mainly from the internal environment.

Tab. 6: Final results – Delphi method

Activities	Managerial function (Kendall's W)	2nd round rank	Change	Final rank
Setting goals and tasks for remote work	Planning (W = 0.82)	1	0	**1**
Changes in financial planning		2	0	**2**
Changes in marketing planning		3	0	**3**
Increased demands on order planning (including international)		4	0	**4**
Selection and allocation of online platforms and infrastructure		5	0	**5**
Delegating tasks	Organising (W = 0.70)	1	0	**1**
Organising employee coverage		2	−1	**3**
Reorganisation and creation of new processes/activities		3	+1	**2**
Creating new structures and teams		4	0	**4**
Ensuring sufficient access to technologies, and tools + training		5	0	**5**
Caring for the mental health of employees	Leading (W = 0.84)	1	0	**1**
Coordination of workplace communication, including keeping employees informed of updates		2	0	**2**
Flexible working hours (adjustment or implementation)		3	0	**3**
New ways of motivation and benefits		4	0	**4**
Increased demands on operational management		5	0	**5**
Increase in feedback provided – due to limited physical contact	Controlling (W = 0.76)	1	0	**1**
Regular monitoring of processes and outputs		2	0	**2**
Control of compliance with standards and regulations		3	0	**3**
Random checks of completed work		4	−1	**5**
Implementation of measures for proactive risk management		5	+1	**4**

Source: own

Tab. 7: Barriers to managerial activities

Identified barrier	Area	Environment
Limited opportunities for employee development and education	Employees	Internal
Employees' illness		
Increased stress – reduced effectiveness of managerial decision-making	Management	
Difficulties in monitoring employees		
Limitation of time resources	Resources	
Lack of resources and limited budget		
Insufficient technological infrastructure	Property	
Restrictions on suppliers (e.g., communication limitations)	Suppliers	Industry
Customers – increased impatience and concerns	Customers	
Government and administration – issuance of regulations	Political/legal	External
Rapid changes in the situation and uncertain prognosis of development	Combination	
Lack of physical contact		

Source: own

4. Discussion

The empirical research revealed some interesting facts about the managerial functions performed during the COVID-19 situation. The results will be discussed according to the order of the findings in the literature, which will be suitably supplemented by the additional results of this research.

As to *RQ1*, in the literature, the most identified changes were related to the leading function. Although each managerial function is represented in this research by exactly five activities, their importance can be derived from the rating (the second round of Delphi) received regarding its performance and importance during the COVID-19 situation. In terms of leading, the activities within this category were highly rated (the average value for the whole group of activities related to leading is the second highest rated with a value of 3.662). Also, in the third round of Delphi, Kendall's W is the highest for the group of activities related to leading function (0.83), which indicates the most robust consensus among experts. This study identified five activities related to leading (third round of Delphi). In the first place was "Caring for the mental health of employees," which directly confirms the findings of Hartmann and Lussier (2020). The second was "Coordination of workplace communication, including keeping employees informed of updates," which is most in line with the findings of Kraus et al. (2020), Manko (2021), and Rashid and Ratten (2021), who were dealing with the communication's specifics during COVID-19. The third, "Flexible working hours (adjustment or implementation)," was not previously identified in the literature. The fourth, "New ways of motivation and benefit," is related to the whole group of (seven) publications that were related to motivation during COVID-19 (Cervinka & Novak, 2022; Hartmann & Lussier, 2020; Koch & Schermuly, 2021; Manko, 2021; Racaite-Samusiene et al., 2021; Rashid & Ratten, 2021; Schleper et al., 2021). The last activity, "Increased demands on operational management" was not previously identified in the literature. Thus, to summarise the managerial function of leading, the changes in motivation and communication identified by the literature were also observed empirically in the Czech Republic. However, the changes related to remote working (identified by SLR) were not, at least not in terms of leading function. Additionally, two activities that SLR did not directly identify resulted from the research. "Flexible working hours" could

be related to remote working; however, the "Increased demands on operational management" is too general and could relate to remote working, as well as motivation or communication.

In terms of organising, while the research of the literature revealed relative importance (9 papers mentioned it), in this research, the activities regarding organising were the lowest rated (average for the whole group of activities is 3.1), also it has the lowest value of Kendall's W (0.7). This study identified five activities related to organising. As the first was the "Delegating tasks," which was a logical consequence of the COVID-19 situation; however, in the literature, no such activity was identified. The second, "Reorganisation and creation of new processes/activities," is directly in line with the findings of Gonçalves et al. (2021), Hartmann and Lussier (2020), Messabia et al. (2022), and Rashid and Ratten (2021), who generally dealt with changes in processes that resulted from the situation. The third, "Organising of employee coverage," relates to the issues of employees identified by Gonçalves et al. (2021), Messabia et al. (2022), and Tomcikova et al. (2021). Regarding the fourth, "Creating new structures and teams," no such topic was previously identified in SLR. The fifth, "Ensuring sufficient access to technologies, and tools + training," was also revealed by Almazrouei and Zacca (2022) and Kraus et al. (2020) in terms of providing necessary technology. The "training" part was additionally mentioned by Gonçalves et al. (2021) and Hartmann and Lussier (2020), but rather in terms of the leading employees being trained rather than organising the training. To summarise the organising function, most of the critical changes identified by literature (7 out of a total 9) were also empirically verified; however, according to this research data, this function was not seen as important as others.

On the other hand, planning was considered by the experts to be the most important (in the second round of Delphi, the average value for the whole group of activities related to planning was the highest rated, with a value of 3.712). Also, Kendall's W was the second highest, with a value of 0.82. This result contrasts the prior SLR, which contained only five papers identifying changes related to this function. This difference can be attributed to many reasons, the most probable being that planning is not as interesting for researchers as leading (leadership) is. As to individual results, the first activity in this group is "Setting goals and tasks for remote work." From the planning point of view, it was not explicitly mentioned in any literature; however, the issue of remote work, e.g., from an organisational or leading point of view, appears in the works of Almazrouei and Zacca (2022), Ayoko et al. (2021), Gonçalves et al. (2021), Hartmann and Lussier (2020), and Kraus et al. (2020). The second and the third are the "Changes in financial planning" and in "Marketing planning," which were not dealt with in any literature, same as the fourth, "Increased demands on order planning (including international"). The last, "Selection and allocation of online platforms and infrastructure," was not directly dealt with from a planning point of view. However, it is related to the communication topic dealt with within the leading function (e.g., Kraus et al., 2020) mentioned WhatsApp or Facebook communication during the COVID-19 situation). Also, the "infrastructure" part can be related to the papers of Almazrouei and Zacca (2022) and Kraus et al. (2020), who dealt with this subject in terms of its organisation. Thus, to summarise, no previously identified changes in the literature were empirically verified regarding planning. Only some similarities were found with research dealing with other functions. However, in this case, the changes identified by the literature were mostly general observations, such as "problematic planning," which is not an activity. Thus, it could not be revealed by this research. Only one exception was the shift to short-term planning observed by Soluk (2022), which was expected to be verified empirically; however, it was not.

The last function of controlling was mentioned only once in literature by Almazrouei and Zacca (2022), who stated that KPI results were worse and that managers had to adapt to monitor employees remotely. In practice, this statement was confirmed by the final set of activities in this research (Tab. 3). As to the overall rating in the second round of Delphi, this group of activities took third place with an average rating of 3.475.

Thus, to summarise, most of the changes identified by SLR in the functions of leading, organising, and controlling were verified empirically, only those in planning were not at all. Additionally, in contrast to the literature, where leading was the most often researched subject, followed by organising, the experts considered

the essential function planning, followed by leading and controlling.

Regarding *RQ2*, the literature identified several difficulties managers faced, with half also verified empirically. The barrier "Lack of resources and limited budget" identified by experts is consistent with the findings of Cervinka and Novak (2022) and Messabia et al. (2022). The barrier "Increased stress – reduced effectiveness of managerial decision-making" confirmed the identified (Cervinka & Novak, 2022; Messabia et al., 2022; Schleper et al., 2021; Soluk, 2022) difficulty of omnipresent stress. Also, the resulting barrier, "Difficulties in monitoring employees," confirms the finding of Almazrouei and Zacca (2022), who mentioned the problems with monitoring employees remotely. Additionally, the resulting barrier of "Employees' illness" points to problems in terms of employees, which was also the difficulty identified from the work of Rashid and Ratten (2021), who were dealing with the necessity to lay off employees (however, that could be caused by other reasons). Other two difficulties identified by literature (a greater amount of work and problems with communication) were not empirically verified in this research. On the other hand, this research revealed many other barriers (Tab. 7) that were not identified in the literature. Interestingly, the experts identified the slightest influence of the external environment and institutions, even though the survey was conducted in the Czech Republic, which was under the influence of unexpected and significant interventions of state institutions during the pandemic.

Conclusions

To conclude, this research verified most of the changes and barriers regarding the performance of managerial functions during COVID-19 that were identified previously in the literature. In addition, this research also revealed many additional changes and barriers that influenced managerial work during the COVID-19 era. It is important to note that the studied literature was primarily aimed at different topics than the changes in managerial functions due to COVID-19. Thus, the high number of previously non-identified activities that this research revealed should not be seen as criticising the literature but instead as complementing existing research.

Regarding the new findings from the Delphi method, the experts agreed that the most important and most often performed were activities related to the function of planning, as well as leading and controlling, from which "Setting goals and tasks for remote work" activity was the most important one. Activities related to organising were rated as the least important, with the activity "Ensuring sufficient access to technologies, and tools + training" as the least important one. These results are surprising because the necessity to react quickly (and thus re-organise resources) was expected to be revealed. The unexpected result can be explained by the fact that this research was aimed at the managers who managed people working from home, who often did not have to deal with the restrictions commanding them to close the business for a while (such as were, e.g., managers of the restaurants). So, the organisation of their employees' work was not seen as an issue compared to planning in such an unstable environment.

Additionally, this research identified several internal barriers that influenced managerial work, which is strange, given that most restrictions came from the external environment. Thus, businesses should work on better crisis management in the future.

Regarding future research, it would be interesting to know the opinions of experts who managed people working from the usual workplace. However, since the COVID-19 restrictions have primarily ended in many countries, and considering that people (managers) tend to forget the wrong things, to start this research now seems unwise because obtained results could be distorted.

As for the limitations of this research, the fact that the research was conducted only in the Czech Republic can be seen as one because different epidemiological measures were applied in every country. However, the measures that influenced the managers and their work the most (e.g., the recommendations/requirements that people stay home as much as possible) were very similar in Europe (with few exceptions).

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Exploring the relationship between usage of social networking sites, cyberbullying and academic performance: Evidence from the higher education sector of Saudi Arabia

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Abstract: *The aim of this study is to investigate the relationship between the use of social networking sites (SNS), cyberbullying (CB) and academic performance (AP). Firstly, we investigate the direct relationship between the use of social networking sites (Instagram, Facebook and TikTok) and academic performance. Secondly, the relationship between the use of social networking sites (Instagram, Facebook and TikTok) and cyberbullying is explored. Thirdly, linkages between cyberbullying and academic performance are examined. Lastly, the mediating effect of cyberbullying in the relationship between the use of social networking sites and academic performance is tested. In this study, we used quantitative survey analysis. We collect data using the research questionnaire from the graduate and postgraduate students enrolled in the universities located in Riyadh, Kingdom of Saudi Arabia. The data were analyzed using the structural equation modeling through SmartPLS 3.2.2. The findings demonstrate that in direct relationships, Facebook and TikTok have a significant relationship with academic performance. However, in the direct relationship, Instagram has an insignificant relationship with academic performance. Similarly, the outcomes confirmed that Instagram, Facebook, and TikTok have a significant relationship with cyberbullying. Furthermore, the outcomes indicate that cyberbullying has a negative impact on academic performance. Finally, the results of this study indicate that cyberbullying negatively mediates the relationship between the use of social networking sites and academic performance. At the end of the study, we have toughly discussed the conclusion, limitations and future research directions.*

Keywords: *Use of social networking sites, Instagram, Facebook, TikTok, cyberbullying and academic performance.*

JEL Classification: *M10, M15, M19.*

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Introduction

The education sector is very important for society. Previously, when the COVID-19 pandemic disturbed the education systems worldwide (Chaudhry et al., 2023; Mohammed et al., 2022), the education system closures occurred, leading to a swift shift to remote learning. To resolve this issue, most educational institutions in the world shifted their education system from offline classes to online classes (Zhu & Liu, 2020). In this regard, educational institutes started frequently using information technology capabilities. Many universities around the world use video conferencing apps and platforms such as Google Meet, Zoom, Skype and Microsoft Teams. Social networking sites (SNS) and social media such as Facebook, Instagram and WhatsApp are used by educational institutes to stay in touch with their faculty and students (Cavus et al., 2021). As a result, post-pandemic, the use of social media and SNS increased exponentially for academic purposes. At the same time, the use of SNS also affects student's academic performance (Raza et al., 2020).

Nwosu et al. (2020) demonstrate that the rapidly increasing use of social media has progressively decreased students' academic performance. The use of SNS has increased its horizons and is becoming more popular amongst students. Social media acts as an important tool that helps make connections (Kietzmann et al., 2011). Many parents have shown concern that their children study less and spend more time using social media and constantly gain exposure to these sites, according to the results of several researchers (Jha et al., 2016; Owusu-Acheaw & Larson, 2015; Upadhayay & Guragain, 2017). Prior studies indicate that social media interaction has doubled over the last few years (Junco, 2012; Lambić, 2016). Especially with popular social media sites such as Facebook, Twitter and WhatsApp, the use of these sites has increased among university students (Lambić, 2016). This has made students use and check their cellular phones more often, after every 5 minutes. Students often distract themselves using their phones; doing homework decreases their focus and performance (Ala'a et al., 2022; Verduyn et al., 2022).

Iqbal et al. (2021) argue that CB has also increased with the increase in social media use. Cyberbullying is one such crime, and it means posting bad thought-related messages, often done with anonymity and anybody knowing. However, students use the internet for multiple reasons, such as educational content and recreational activities to kill time. Similarly, CB has become a recreation factor for students. It involves posting and expressing opinions on personal information. Some even make pages where they troll them for being bullied (Giumetti & Kowalski, 2022). Being anonymous and having access to the internet, which facilitates bullies with large instant audiences, can affect the students during the time they study (Chan et al., 2021). Furthermore, the extensive uses of SNS have their own significance in the digital era and CB. The 21st century has numerous challenges; among these challenges, digital threats or CB is one of the challenges facing the world. Currently, more than 82% of residents in Saudi Arabia use the SNS as part of their daily lives. In the modern age, digital threats, or CB, spread all over the world. Saudi Arabia is also facing CB challenges as the rest of the world is facing them. So, many people, especially young students, face CB, which increases the stress and depression among the young people of Saudi Arabia.

Saudi Arabia is a developed economy and the fourth largest country in the Middle East (El Mallakh, 2015). The population of Saudi Arabia is 36 million, and the people of Saudi Arabia actively use SNS. Saudi Arabia's youth (14–35 years) represent 35% of the total population. Therefore, more than 70% of the youth population of Saudi Arabia are students. The students enrolled in Saudi Arabian universities are massive users of SNS (Alamri, 2019). Recently, Alwagait et al. (2015) revealed that social media use increased in Saudi Arabia by 6% (1.5 million) in 2022 compared to 2021. Saudi Arabia has 30 million social media users (82.3% of the population). However, 11.4 million

are Facebook users, 15.5 million are Instagram users, and 22.5 million TikTok users (Alamri, 2019). The above statistics highlighted that many SNS are used in the Kingdom of Saudi Arabia, but Facebook, TikTok and Instagram are messily used compared to other SN.

Previously, few studies investigated the direct association between SNS and AP (Alamri, 2019; Alwagait et al., 2015; Fati, 2022), but the three-way relationships between USNS, CB and AP are unexplored. Similarly, these studies were conducted in Europe, the USA, South Asia and African countries (Junco, 2012; Kalam et al., 2023; Karpinski et al., 2013). This is the first novel study conducted in Saudi Arabia. However, it is a novelty of the research to explore the impact of SNS on the youth of Arab society. Moreover, in previous studies, authors did not use Instagram, Facebook and TikTok as independent variables. So, this is the first study that investigates the connection between Instagram, Facebook, TikTok and AP in Saudi Arabia. Furthermore, the novelty of this study is to test CB as a mediating variable in the relationship between the use of SNS and AP. This research aims to find the association between the use of SNS, CB and AP. First, we investigate the direct relationship between SNS (Instagram, Facebook and TikTok) and AP. Secondly, this study explores the relationship between the use of SNS (Instagram, Facebook and TikTok) and CB. Third, this study examines the relationship between CB and AP. Fourth, we examine the mediating effect of CB in the association between SNS (Instagram, Facebook and TikTok) and AP. So, based on the above discussion, we proposed two research questions (*RQ*) below, to fulfil this study's objective and aims.

RQ1: How does using social networking sites affect students' academic performance in Saudi Arabia?

RQ2: Does cyberbullying mediate the relationship between the use of social networking sites and academic performance?

The structure of this research is as follows. The hypothesis development and conceptual framework are presented in the first section. The second section focuses on the research methods. The third section describes the results and analysis. The fourth section contains a discussion and conclusion. The last section describes the implications and future research directions.

1. Theoretical background

1.1 Use of social networking sites and academic performance

Researchers define social network sites as online platforms people use to build social relationships with others who share similar personal or career content, interests, activities, backgrounds, or real-life connections (Foroughi et al., 2022). However, the concept of AP means the individual achievement of students from different academic subjects. Educationists are concerned about SNS effect on learners' AP and achievements. Students are spending too much time on USNS, such as Instagram, Facebook and TikTok. Therefore, the use of SNS has become an essential part of student's daily life (Chang et al., 2018; Foroughi et al., 2022). Similarly, Giunchiglia et al. (2018) demonstrate that the use of SNS is easily accessible on smartphones, which attracts students to engage with the use of SNS. So, students spend most of their time on social media instead of studying. Matt et al. (2015) argue that young students spend a lot of time on the use of SNS, and as a result, it affects their sleeping time, which also affects their AP (El Abiddine et al., 2022). Another study by Slot and Opree (2021) noted that students' unnecessary allocation of time to Facebook, TikTok and Instagram is inversely correlated to their grade point achievements, time management, and concentration on their studies. Similarly, Liao et al. (2021) discovered that the AP of the students who use SNS extensively (Facebook, Instagram, and TikTok) is weaker than that of those who do not use SNS extensively. It is also noted that the extensive use of SNSs also increases students' stress, ultimately decreasing their learning ability. However, poor learning ability decreases the students' performance (Hosen et al., 2021). Backed by these arguments, we propose the following hypotheses:

H1a: Use of Instagram has a negative relationship with academic performance.

H1b: Use of Facebook has a negative relationship with academic performance.

H1c: Use of TikTok has a negative relationship with academic performance.

1.2 Use of social networking sites and cyberbullying

Beran and Li (2005) define CB as using online resources to harm others in a hostile, repetitive, and conscious manner. These days, technological advancements have made our lives

easier. However, positive uses of technologies bring innovations and work efficiently to perform any task. Similarly, the users who are not utilizing technologies purposefully also get negative outcomes. The extensive use of SNS may lead to physical, psychological and personal security-related issues. Abaido (2020) highlights in their study that the extensive use of social media increases cyberbullying. Therefore, the victims of cyberbullying may face stress, depression and anxiety-related issues. The essential negative aspects of these online technologies' usage are aggressive behaviours such as insults, stalking, verbal abuses, and threats through the use of SNS such as Facebook, Instagram, and TikTok. Especially the use of social media by juveniles has become a big problem for CB. Robers et al. (2015) found that most students of the age 12–18 years reported that they were the victim of CB at least twice a year. Ding et al. (2020) noticed many people face CB in social media environments such as Instagram, Facebook, and TikTok. Extensive use of social media networks enhances the interaction of individuals with people of fake profiling and abusive behaviour. These abusive behaviours include sharing other people's personal information, stalking, threats and spreading rumors. Therefore, we have posed the following hypotheses based on discussion:

H2a: Extensive uses of Instagram upsurge the cyberbullying.

H2b: Extensive uses of Facebook upsurge the cyberbullying.

H2c: Extensive uses of TikTok upsurge the cyberbullying.

1.3 Cyberbullying and academic performance

Academic performance is a variable based on quantitative and qualitative measures that reflect the learners' knowledge, skills, values, and attitudes as a result of the teaching-learning process (Navarro, 2003). Prior studies represent indecisive results of CB and AP (Al-Rahmi et al., 2022; Clark-Gordon et al., 2017; Malik et al., 2020). The outcome of Macías (2010) found a negative relationship between CB and AP. However, CB has a more negative influence on the AP of learners. Torres et al. (2020) conducted the study in Spain, and the findings of their study demonstrate that university students in Spain with lower self-esteem suffered from CB in Facebook environments, which resulted in poor AP. Research by Martínez-Martínez et al. (2020) investigated different social media network sites such as TikTok, Facebook, and Instagram and found that United States universities have shown a negative influence of CB on their AP. Okumu et al. (2020) conducted a study among university students, and their study results suggest that young students are using the SNS extensively. Hence, these young students also become the victims of CB, increasing their stress, depression, and anxiety level, negatively affecting the AP of these students. Therefore, we have posed the following hypotheses based on discussion:

H3: Cyberbullying has a negative relationship with academic performance.

1.4 Mediating effect of cyberbullying

Social media is a very important aspect of the modern age. Modern communication among young people mostly relies on the use of SNS such as Facebook, WhatsApp, Instagram, and TikTok. Social media networks provide various benefits, but their extra use also causes various negative impacts (Maftei et al., 2022; Plaisime et al., 2020). Among the various negative impacts of the extra use of social media networks, CB is a typical one, causing not only mental but also social and economic problems (Chan et al., 2021). Prior studies suggest that CB is characterized by a transformation from traditional bullying forms to online forms through the use of social media platforms (Bastiaensens et al., 2014). Recent research conducted in the UAE has revealed that CB is a considerable problem for the users of social media platforms, especially adolescents, which leads to low AP (Ercag, 2021). Alotaibi (2019) conducted a study in Saudi schools, and the outcomes of their study indicate that the CB negatively affects the student's academic achievement. Earlier studies demonstrate that extensive uses of SNS (i.e., Facebook, TikTok, WhatsApp, and Instagram) increase CB, ultimately affecting students' academic achievement (Brody et al., 2016; Gahagan et al., 2016). However, the above discussion has proven that CB mediates the relationship between the use of SNS and AP. Therefore, we propose the hypotheses based on the above literature. Moreover, Fig. 1 presents the comprehensive theoretical framework of this study.

H4a: Cyberbullying mediates the relationship between the use of Instagram and academic performance.

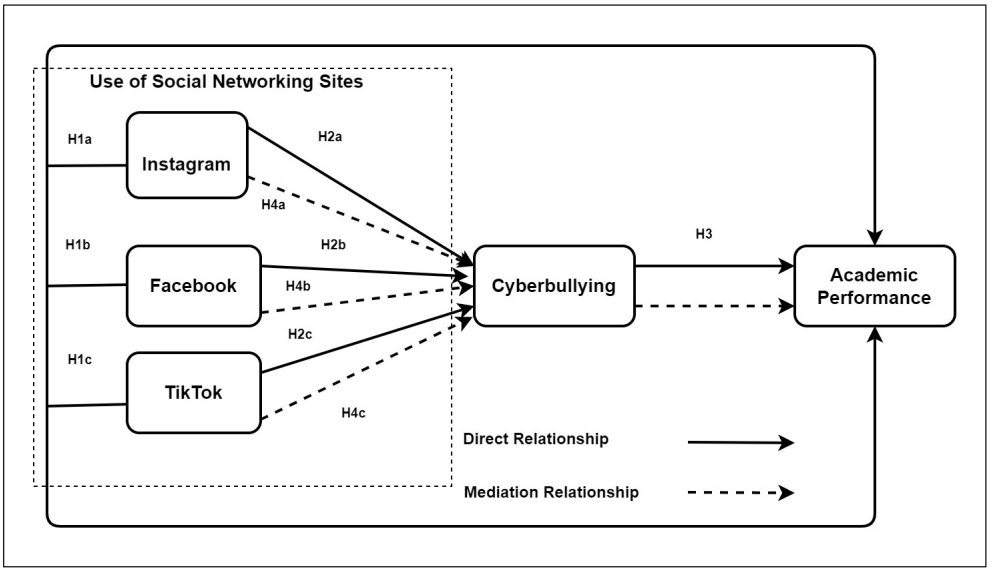

Fig. 1: Theoretical framework

Source: own

H4b: Cyberbullying mediates the relationship between the use of Facebook and academic performance.

H4c: Cyberbullying mediates the relationship between the use of TikTok and academic performance.

2. Research methodology

2.1 Research approach

In this study, we used the survey analysis approach to explore the relationship between the use of SNS, CB and AP (Amin et al., 2023). We used this research approach because it allows us to easily collect data from the target population (Jia et al., 2022). Moreover, the survey analysis approach is a low-cost approach to collecting data (Akram et al., 2019).

2.2 Questionnaire designing

A research questionnaire was used to collect data. The first part of the questionnaire consists of demographic data, which consists of the respondents' personal information. The second part consists of the items of use of SNS, CB and AP adopted by Iqbal et al. (2021), Laffan et al. (2022), and Iqbal et al. (2022). We use a five-point Likert-type scale ranging from 1 = strongly disagree to 5 = strongly agree. Before data collection, pilot testing with small data was conducted to confirm the validity and reliability of the draft questionnaire. In the pilot study, we distributed 10 questionnaires among the university professors who are aware of the research topics. Moreover, we also distributed 10 research questionnaires among the university students enrolled in the Kingdom of Saudi Arabian universities. In light of the pilot study, a few minor revisions were suggested by the pilot study respondents. However, before conducting the complete research procedure, we improved the research questionnaire.

2.3 Variables measurements

The scale of use of SNS was adopted by Iqbal et al. (2022). The scale consists of three sub-dimensions, i.e., Instagram, Facebook and TikTok. The items of use of SNS were measured using 5-point Likert scale. Cronbach's alpha values of Instagram, Facebook and TikTok were 0.677, 0.852 and 0.741, respectively. Therefore, the outcome value of Cronbach's alpha is up to the acceptable value. The sample items on the use of SNS are as follows: "Email or other electronic means (such as Instagram,

Facebook, and TikTok) to share content with other students and teachers are very useful"; "I use Instagram to receive help from my teachers and classmates"; "I usually postpone my academic task to spend more time on Facebook"; and "I use TikTok to disseminate knowledge to my classmates."

The items scale of CB is adopted from Abaido (2020) and modified according to our study. The 5-point Likert scale items score as strongly disagree (1) and strongly agree (5). Cronbach's alpha value of CB was 0.872. Therefore, the outcome value of Cronbach's alpha is up to the acceptable value which is more than 0.70 (Samma et al., 2020). The sample items of CB were: "Over the last three years, I have had many CB experiences using SNS such as Instagram, Facebook and TikTok"; and "CB mentally and emotionally affects my behaviour and my AP."

The scale of AP was developed by Iqbal et al. (2021). The 5-point Likert scale items score as strongly disagree (1) and strongly agree (5). The Cronbach's alpha value of AP was 0.794. Therefore, the outcome value of Cronbach's alpha is up to the acceptable value which is more than 0.70 (Zaman et al., 2022). The sample items of AP were: "My grades have not improved since I became engaged in these SNS"; and "I feel that due to extensive uses of social media, I am distracting to my academic learning activities."

2.4 Sampling and data collocation

We collected data from the universities located in Riyadh, Kingdom of Saudi Arabia. We selected this city because it is a capital city, and most universities in the Kingdom of Saudi Arabia are in Riyadh. However, using the multistage sampling first, we selected the two universities randomly. Later, we randomly selected one department from each selected university. Each department was considered as a cluster because we have taken all students enrolled in the departments. In the first university, we distributed 400 research questionnaires among postgraduate and undergraduate students and received 257 questionnaires (64.25%). Similarly, in the second university, we distributed 300 research questionnaires and received 183 (61%). We distributed a total of 700 questionnaires, and the total number of respondents was 440 (62% of the questionnaires).

2.5 Demographics

This study was conducted among university students. A total of 440 university students participated; among these students, 62.50% were female, and 37.50% were male, who continued their undergraduate (56.36%) and postgraduate (43.63%) education in the Kingdom of Saudi Arabia. Moreover, the students were 18–20 years (27.27%), 20–25 years (51.59%) and above 25 years old (21.13%). A detailed description of the respondents is given in Tab. 1.

Tab. 1: Demographics profile of the participants

Measure	Items	Frequency (*n*)	Percentage (%)
Gender	Male	275	63
	Female	165	37
	Total	440	100
Education	Undergraduate	248	56
	Graduate	192	44
	Total	440	100
Age (years)	18–20	120	27
	20–25	227	52
	Above 25	93	21
	Total	440	100

Source: own

2.6 Data analysis

SmartPLS 3.2.8 was used for data analysis. There are three main reasons to adopt SmartPLS. First, SmartPLS is a powerful tool for regression analysis. Second, it is particularly advantageous when working with small sample sizes and non-normal data distributions. Third, with its user-friendly interface and robust inferential techniques like bootstrapping, SmartPLS enables researchers to explore and validate theoretical models, estimate path coefficients, and make predictions based on the model.

The analysis was comprised of CFA path analysis. We measured the inner and outer models. PLS-SEM was used in this study because it is considered the most appropriate technique for performing the multivariate analysis. The first step in regression analysis using SmartPLS is to specify the theoretical model. This involves defining the association between latent constructs and observed variables for existing theories (Alareqe et al., 2022). We created a graphical representation of the model using the SmartPLS interface, specifying the direction and strength of the relationships. Additionally, the model included indicators of latent variables and mediating variables. Once the model was specified, SmartPLS performed an estimation procedure to estimate the parameters and test the significance of the relationships. SmartPLS used a partial least squares (PLS) algorithm, which estimated the path coefficients between variables. The algorithm was iterative and sought to maximize the explained variance in the dependent latent variables. After estimation, researchers evaluated the model fit and the significance of the estimated parameters. This involved examining the path coefficients, assessing the *R*-squared values, and conducting statistical tests such as bootstrapping to determine the significance of relationships and mediation moderation effects.

Tab. 2: Reliability and composite reliability – Part 1

Constructs	Coding	Loading	Cronbach's alpha	Rho_A	CR	AVE
AP	AP1	0.859	0.794	0.801	0.867	0.621
	AP2	0.778				
	AP3	0.782				
	AP4	0.734				
	AP5	0.757				
	AP6	0.650				
CB	CB1	0.762	0.872	0.872	0.901	0.565
	CB2	0.763				
	CB3	0.754				
	CB4	0.746				
	CB5	0.745				
FB	SNF1	0.729	0.852	0.866	0.901	0.697
	SNF2	0.730				
	SNF3	0.726				
	SNF4	0.750				
	SNF5	0.746				
	SNF6	0.773				
	SNF7	0.796				

Tab. 2: Reliability and composite reliability – Part 2

Constructs	Coding	Loading	Cronbach's alpha	Rho_A	CR	AVE
IG	SNI1	0.840	0.677	0.724	0.818	0.603
	SNI2	0.702				
	SNI3	0.737				
	SNI4	0.792				
	SNI5	0.729				
	SNI6	0.602				
	SNI7	0.632				
TT	SNT1	0.842	0.741	0.804	0.839	0.579
	SNT2	0.710				
	SNT3	0.837				
	SNT4	0.704				
	SNT5	0.695				
	SNT6	0.739				

Note: AP – Academic performance; CB – cyberbullying; FB – Facebook; IG – Instagram; TT – TikTok.

Source: own

3. Results and analysis

3.1 Evaluation of measurement model

The first step in conducting CFA is to establish an outer model that involves specifying the association between items and relevant factors, as well as assessing the consistency. Since we collected data with a self-reported questionnaire, there were great chances of same source bias. We utilized factor analysis to create a single principal component factor. Therefore, Harman's one-factor test measured the same source bias. According to Podsakoff et al. (2003), the results should be less than 50%. It was 37.4%, indicating that the factors exhibited no common method bias.

Factor loading for all items was satisfactory as it was above 0.4, ranging from 0.602 to 0.859. (Samma et al., 2020) suggested that the standard value of Cronbach's alpha, rho alpha (rho_A) and composite reliability (CR) are higher than 0.7. Tab. 2 indicates that the given values were up to acceptable standards.

3.2 Discriminant validity

The Heterotrait-Monotrait (HTMT) ratio measures the discriminant validity of constructs

Tab. 3: Convergent validity HTMT

Constructs	AP	CB	FB	IG	TT
AP					
CB	0.619				
FB	0.629	0.68			
IG	0.493	0.818	0.646		
TT	0.59	0.679	0.696	0.67	

Note: AP – Academic performance; CB – cyberbullying; FB – Facebook; IG – Instagram; TT – TikTok.

Source: own

in PLS-SEM (Hair Jr. et al., 2017). It indicates the extent to which two constructs differ from each other and do not measure the same traits. The discriminant validity was measured through HTMT values. The HTMT ratio was observed below 0.9, as suggested by Iqbal et al. (2021). Moreover, a detailed description of each construct is given in Tab. 3.

3.3 Evaluation of inner model

The inner model evaluation was performed. It involves the measurement of VIF stats, direct and indirect relations, R^2 coefficient determination, relevance predictivity, f^2 effect size, and goodness of fit.

VIF values

A detailed description of the VIF values is given in Tab. 4. The VIF values were below the threshold, less than 0.5, reflecting the absence of multicollinearity. The outcome of the analysis performed through the SmartPLS indicates no issue of multicollinearity found in the VIF stats.

Model fitness

We used SRMR and NFI as fit indicators available in SmartPLS. Asghar et al. (2023) recommended that the SRMR value must be less than 0.08, while the NFI should be above 0.8. The model fit indices in this analysis showed that the NFI was 0.834 and the SRMR was 0.052, which satisfies the model fitness criteria. Unlike AMOS, SmartPLS does not provide all fit indices except for NFI, SRMR, d_ULS, and d_G (Hair Jr. et al., 2017). Tab. 5 presents the model fitness of this study.

R-square

Prior studies suggest that the R^2 values must be higher than 0.1 to prove a minimum level of impact of the exogenous construct on the endogenous construct. The results of this study showed that the *R*-square were more than the threshold of 0.1 (Tab. 6).

Effect size (f^2)

The influence of an exogenous variable on the endogenous variable is tested by f^2. The f^2 is considered strong with values above 0.15, moderate above 0.02 and weak below 0.02. The comprehensive findings of f^2 values are shown in the summary (Tab. 7).

3.4 Direct coefficient

The β values were used to assess the hypothesis. The outcomes of the direct association between exogenous and endogenous variables

Tab. 4: Inner VIF

Constructs	AP	CB
AP		
CB	2.194	
FB	1.952	1.752
IG	1.884	1.501
TT	1.908	1.796

Note: AP – Academic performance; CB – cyberbullying.

Source: own

Tab. 5: Model fitness

Fit indices	Saturated model	Estimated model
SRMR	0.052	0.062
NFI	0.834	0.889

Source: own

Tab. 6: Coefficient of determination R^2

Constructs	*R*-square	*R*-square adjusted
AP	0.36	0.353
CB	0.544	0.541

Note: AP – Academic performance; CB – cyberbullying.

Source: own

Tab. 7: Effect size f^2

Constructs	AP		CB	
	Stats	Effect	Stats	Effect
CB	0.051	Moderate		
FB	0.057	Moderate	0.114	Strong
IG	0.000	No	0.255	Strong
TT	0.021	Moderate	0.063	Moderate

Note: AP – Academic performance; CB – cyberbullying; FB – Facebook; IG – Instagram; TT – TikTok.

Source: own

indicate that all direct relationships are significant. However, the relationship between Instagram and AP (*p*-value greater than 0.50) is insignificant. Bootstrapping assessed the *p*-values (Chin, 1998; Tab. 8).

3.5 Indirect path coefficient

Tab. 9 explains the indirect relationship between SNS, i.e., Instagram, Facebook, TikTok, CB, and AP. Results revealed that CB negatively mediates between Instagram and AP (β = −0.110, $p < 0.05$). Moreover, CB also negatively mediates between Facebook and AP (β = −0.075, $p < 0.05$). Furthermore, the outcomes confirmed that CB is negatively mediated between TikTok and AP (β = −0.058, $p < 0.05$). However, the detailed description of indirect path coefficients is given in detail in Tab. 9 and Fig. 2.

Tab. 8: Direct path coefficient

Hypothesis	Constructs	β	*t*	*p*-values	Status
H1a	IG → AP	0.009	0.270	0.787	Rejected
H1b	FB → AP	−0.258	4.830	0.000	Accepted
H1c	TT → AP	−0.177	2.831	0.005	Accepted
H2a	IG → CB	0.431	8.628	0.000	Accepted
H2b	FB → CB	0.292	6.937	0.000	Accepted
H2c	TT → CB	0.228	4.683	0.000	Accepted
H3	CB → AP	−0.256	4.259	0.000	Accepted

Note: AP – Academic performance; CB – cyberbullying; FB – Facebook; IG – Instagram; TT – TikTok.

Source: own

Tab. 9: Indirect path coefficient

Hypothesis	Constructs	β	Standard deviation	*t*	*p*-values	Status
H4a	IG → CB → AP	−0.110	0.030	3.727	0.000	Accepted
H4b	FB → CB → AP	−0.075	0.022	3.639	0.000	Accepted
H4c	TT → CB → AP	−0.058	0.019	3.226	0.001	Accepted

Note: AP – Academic performance; CB – cyberbullying; FB – Facebook; IG – Instagram; TT – TikTok.

Source: own

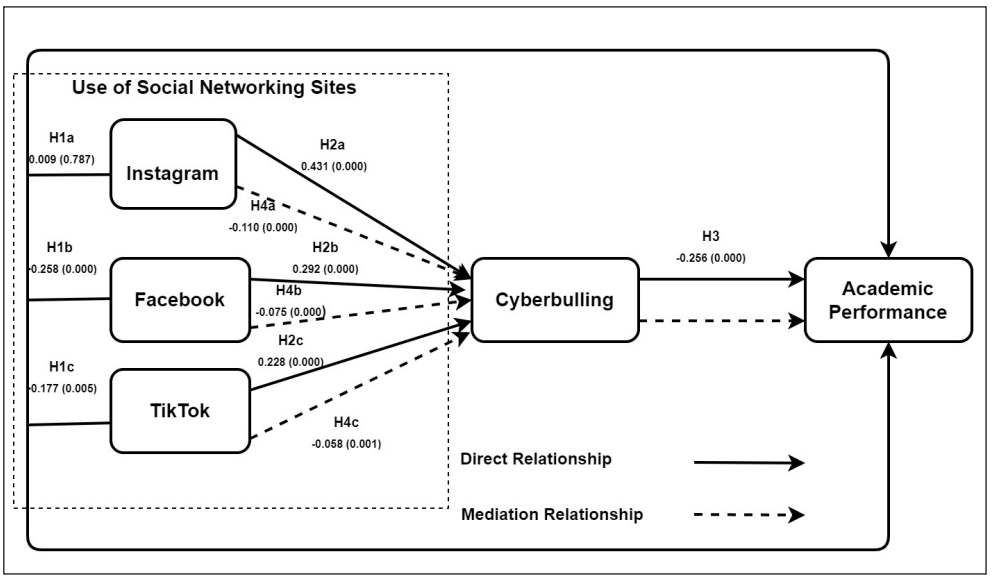

Fig. 2: Path analysis

Source: own

4. Discussion

The aim of the study was to investigate the direct and indirect connection between the use of social networking sites (i.e., Facebook, TikTok, Instagram), cyberbullying and academic performance. The model was tested in four phases. In the first phase, the direct relationships between the use of social networking sites and academic performance were tested. In the second phase, the relationship between social networking sites and cyberbullying was assessed. The third phase examined the linkages between cyberbullying and academic performance. Lastly, the mediation mechanism of cyberbullying for the relationship between social networking sites and academic performance was tested.

The results of hypotheses *H1a*, *H1b*, and *H1c* explain the direct negative relationship between academic performance and social networking sites, i.e., Instagram, Facebook, and TikTok. The findings demonstrate that *H1b* and *H1c* are accepted with β coefficient values of −0.25 ($p < 0.05$) for Facebook and −0.177 ($p < 0.05$) for TikTok, respectively. However, the proposed negative relationship between Instagram and academic performance was not accepted, with an insignificant β value of 0.009

(p = 0.78). These results are consistent with the findings of Azizi et al. (2019); the authors conducted a study among 360 Iranian medical sciences students. Their result showed a significant negative relationship between students' use of social media sites and academic performance. This similarity bolsters the fact that despite its crucial role in learning and communication in academia, social media's negative impact can outweigh its benefits. It damages the physical and psychological health of the students and produces mental disorders, stress and anxiety (Ramesh Masthi et al., 2018). Moreover, results are also aligned with the social influence theory, which suggests that individuals can experience a modification in their behaviours (intentionally or unintentionally) under the pressure of an influencer based on the strength of their relationship. Social media is a source of influence. This influence can be negative or positive depending on the individual's own personality. The use of social networking sites creates excessive pressure on college students to conform with the trends. Students disregarding these trends are viewed as old-fashioned and outdated. Consequently, the majority of college students dedicate a good share of their time to using social media for their survival (Iqbal et al., 2021). Likewise, social media addiction is also linked with procrastination and laziness (Latipah et al., 2021). These behaviours eventually lead to deteriorating academic performance.

The outcome of this study indicates that the *H2a, H2b* and *H2c* are accepted. This indicates that ample use of social media platforms by college students makes them more prone to cyberbullying. Social networking sites host millions of users worldwide, including perpetrators who can identify and target vulnerable individuals (Chan et al., 2019). This result is consistent with the results of Çimke and Cerit (2021), the researchers investigated 518 health sciences students to identify the link between social networking sites and cyberbullying. Their findings revealed that students with higher social media addiction experience a higher level of cyberbullying. The rationale behind this positive relationship can be the fact that social media is a big part of college life, where students like to be in touch with each other for academic and extra circular activities. However, due to the high accessibility and manipulative nature of social media, perpetrators can easily make fake profiles, stay anonymous and violate victim's privacy, and cyberbullying can be more easily executed.

The finding of hypothesis *H3*, stating a negative relationship between cyberbullying and academic performance, was supported by $\beta = -0.25$ ($p < 0.05$). This depicts that students experiencing high cyberbullying will exhibit low academic performance. The logical verification of this relationship is backed by the fact that cyberbullying has a deep-rooted psychological and emotional impact on individuals (Chan et al., 2019). People facing cyberbullying are under constant pressure to preserve their self-image and shield themselves from negative comments and judgments. They experience high stress, anxiety and depression (Çimke & Cerit, 2021). Consequently, students experiencing cyberbullying will spend more time counter-fighting it than focusing on the academic requirements. The results are consistent with the findings of Martínez-Martínez et al. (2020), where investigators tested the relationship between cyber victimization and academic performance on a sample of 3,451 secondary school adolescents. Their findings revealed a negative relationship between cyber victimization and academic performance.

The results of hypothesis *H4*, proposing a mediation mechanism of cyberbullying for the relationship between the uses of social networking sites and academic performance, were also supported for Facebook, TikTok and Instagram. The outcomes also indicate that cyberbullying channelizes the negative relationship between the use of social networking sites and academic performance. This shows that exposure to cyberbullying is linked with various negative outcomes like depression and anxiety stress, which can, in turn, affect academic performance.

Limitations and future research directions

As no study can be perfect in all aspects, the current study also has some limitations. Firstly, it is a cross-sectional study, and researchers like Malhotra et al. (2017) have argued that the common method variance can be a concern for cross-sectional studies. Future research can be undertaken by using the time lag method to remove common method bias. Similarly, the study was done in the narrow cultural context of Saudi Arabia, where the internet is accessible. Moreover, in the Kingdom of Saudi Arabia, the use of social

networking sites is freely available, and cyberbullying among university students is increasing day by day. The same study can be replicated in countries with tight cyber security rules, and a comparison can be drawn between these two different contexts. In a similar fashion, the concept of bullying can be context-specific as well. The study was conducted in the Kingdom of Saudi Arabia, where bullying is part of academic life and integral to social closeness and bonding. Future studies should be undertaken in more individualistic societies to produce generalized results. Lastly, the current study has not configured the role of personal characteristics in handling the negative effects of cyberbullying on academic performance. Personal characteristics like personality, emotional intelligence, and self-efficacy can shape one's coping strategies of cyberbullying. Personality factors and personal skills and attitudes can be taken as moderators of the relationship between cyberbullying and academic performance in future studies.

Conclusions

This study aimed to assess the relationship between the use of social networking sites, cyberbullying, and academic performance. The findings concluded that increased usage of social networking sites platforms such as Facebook and TikTok was associated with a decrease in academic performance, highlighting the negative impact of social media on student outcomes. Additionally, a positive correlation was observed between cyberbullying and usage of social networking sites, indicating that social media use among students has been linked to a rise in online harassment incidents. The ease of connectivity can amplify negative behaviours, necessitating efforts to promote digital well-being and combat cyberbullying. Similarly, the outcomes of this study demonstrate that cyberbullying negatively affects the academic performance of students. As a result, students face psychological issues such as stress, burnout, anxiety, and depression. Moreover, this study concludes that frequent use of social networking sites increases cyberbullying among students, which also affects the academic performance of the students. Similarly, persistent online harassment may lead to decreased self-esteem and increased stress levels, affecting academic performance. So, the higher education sector must create awareness, implement preventive measures, and foster a positive online culture, which is crucial in mitigating these adverse effects.

This study recommends some strategies that will reduce cyberbullying and increase the student's academic performance. First, the higher education sector implements comprehensive digital literacy programs to educate students on responsible online behaviour, recognizing and reporting cyberbullying. Second, the higher education sector establishes anonymous reporting mechanisms to encourage students to report instances of cyberbullying without fear of retaliation, fostering a safer online environment. Third, the higher education sector of emerging countries like Saudi Arabia promotes peer support programs where students can help each other navigate online challenges, creating a supportive community against cyberbullying. Fourth, the higher education sector connected with the parents and encouraged them to engage actively in their child's online activities, fostering open communication about potential issues and reinforcing positive online behaviour. Fifth and last, the higher education sector incorporates regular mental health check-ups and counselling services to address the emotional impact of cyberbullying, promoting overall well-being and academic success.

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Optimization of inventory cost control for SMEs in supply chain transformation: A case study and discussion

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Abstract: *With the continuous transformation of supply chains in various industries in China, the strategic landscape, industrial structure, industry rules, business models, and management logic have all changed dramatically, and the consumer market has become more demanding regarding pre-sales quality and after-sales service. Primarily for distribution companies whose primary business model is "buy and sell products and earn a profit margin," the supply chain transformation has placed higher demands on inventory cost control. In this study, we propose an integrated approach for optimization of inventory cost control of internal supply chain management. The integrated approach includes an improved ABC inventory classification method, spare parts demand forecasting, and an adapted inventory management method. We then select a small and medium-sized home appliance distribution company as the case study because the company is at its early stage of inventory transformation due to the supply chain transformation. Using the case study and field research methods, we analyzed the specific impact of supply chain transformation on the company's inventory cost control and demonstrated the efficiency of the integrated approach. This study finds that the case company can control inventory costs more efficiently and effectively after implementing the improved ABC inventory classification method. The proposed different demand forecasting plans can help improve the accuracy of spare parts demand forecasting. Finally, different inventory management methods based on different classifications of spare parts can help determine the appropriate spare parts ordering point and procurement quantity.*

Keywords: *Supply chain, transformation, inventory cost, spare parts, distribution company.*

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Introduction

Supply chain transformation requires the support of information technology (IT) and other innovative digital technologies such as blockchain, internet of things (IoT), big data, and cloud computing. The rapid development of these technologies has facilitated business model innovation. Among other things, digital technologies can improve the overall management efficiency of the supply chain by optimizing workflow, improving information sharing, enabling information transparency, reducing collaboration costs, and increasing the accuracy of production forecasts (AlMulhim, 2021;

Attaran, 2020; Bigliardi et al., 2022; Chowdhury et al., 2019; Guo et al., 2022; Li et al., 2023; Perano et al., 2023; Pflaum et al., 2023). Over the years, the focus of supply chain operations in various industries has gradually shifted from partners to consumers (Basu, 2023; Chapman et al., 2003; MacCarthy et al., 2016; Min et al., 2019). In the traditional consumer market, the information transmission and channel construction costs between home appliance companies and the consumer market are too high, so the channel dealers directly facing the consumer market often have a greater right to speak. However, in the e-commerce market, each node of the supply chain can directly grasp a large amount of information about the consumer market, so the rights of channel merchants are gradually weakened, and the rights of consumers are strengthened. On this basis, a consumer-centric product and service supply model is gradually formed.

A distributor is an entity or individual that provides sales or services only in a specific area and field. As an essential part of the distribution channel, dealers, especially small and medium-sized home appliance distribution companies, face serious supply chain transformation challenges. For example, fierce competition among core enterprises in the supply chain has led to increasingly thin profits in the entire home appliance industry; direct sales by manufacturers have made the market competition more and more intense; the phenomenon of annexation by large companies has also made the survival of small and medium-sized distribution companies more and more difficult. Small and medium-sized distribution companies are disadvantaged regarding business scale, capital strength, and management level. As a result, such companies have the slowest and most pronounced response to macroeconomic regulation and changes in market supply and demand and the weakest ability to cope with market fluctuations and risk crises. For this reason, small and medium-sized home appliance distribution companies urgently need to seek reliable and stable profitability and appropriate ways to survive.

Cost competition is one of the most effective means of modern competition (Kharub et al., 2019; Porter, 2008; Sui & Wei, 2000), and the primary goal of supply chain management (SCM) is to minimize the total cost of the supply chain. In this regard, inventory cost usually accounts for over 30% of the total supply chain cost (Yu et al., 2019). The purpose of companies holding inventory is to obtain more economic benefits, but holding a large amount of inventory will take up too much liquidity for companies. As a result, inventory cost control is the focus of supply chain cost management. The more mature the inventory cost control system is, the better the industry's supply chain management system will be. In this research, we will have a close study of inventory cost control using a case study of the home appliance industry in China as this industry is undergoing a significant digital transformation due to the current trend of the "digital economy" and "new retail model" based on the internet, consumer demand, data (technology) drive, and channel integration.

1. Theoretical background

1.1 Supply chain management and transformation

SCM refers to the management of the supply chain; in other words, it is the coordination, integration, optimization, monitoring, and control of the physical, information, and financial flow activities of the production, manufacturing, and marketing chain of each nodal enterprise (Basu, 2023; Christopher, 2016). Shen et al. (2000) analyzed the literature and they concluded that SCM can usually be divided into two categories: internal supply chain management (e.g., planning, procurement, production, sale) and external supply chain management (e.g., supplier, consumer). SCM has both short-term and long-term objectives. Short-term objectives are to increase production capacity, reduce various costs such as inventory, communication, financial, and logistics costs, and reduce product cycle time. Long-term objectives are to improve customer satisfaction, market share, and profitability.

Strategic transformation refers to an organization's strategies to adapt to its business environment (Cohen & Roussel, 2013; Holtström, 2022). Specifically, it refers to the upgrading or renewal of organizational characteristics that affect the long-term organizational vision at the process, impact, and outcome levels. Strategic upgrading and renewal include two types of strategic transformation: reconfiguration and incremental (Agarwal & Helfat, 2009). The main drivers of strategic reconfiguration transformation come from external technological developments, changes in consumer demand, and the degree of market

maturity or decline. Reconfiguration strategic transformation does not only refer to changes in organizational processes. It also involves renewing the business model, technology base, organizational structure, resource capabilities, and trends (Ben-Menahem et al., 2013; Holtström, 2022; Tripsas, 2010).

Supply chain transformation is a strategic upgrading behavior led by the core companies of the supply chain. Core companies need to meet three conditions to complete supply chain transformation: first, selectively use or obtain support from existing resources; second, make full use of network resources to build supply chain capabilities; and finally, complete strategic upgrading and renewal of the supply chain (Xiao, 2015). In recent years, due to the advancement of IT and other digital technologies supply chain is undergoing a rapid transformation. Ageron et al. (2020) focused on challenges and future directions in digital supply chain and found supply chain transformation research is centered on two big areas: innovative technologies and strategic, organizational and human dimensions of the digital supply chain. Preindl et al. (2020) discussed a number of supply chain transformation strategies based on the impact of Industry 4.0 and digital transformation. Ho et al. (2023) developed a framework for developing digital strategies for supply chains. Alzarooni et al. (2022) analyzed the literature and in combination with expert opinions in the United Arab Emirates, they found three significant enablers (smart warehousing, intelligence, real-time) for digital supply chain transformation in the service industry. Aamer et al. (2023) identified three main themes (technology, people and processes) and ten drivers (e.g., IT infrastructure) for assessing the readiness for supply chain digitalization. Some research is on enabling sustainable supply chain transformation using different methods such as using real-coded genetic algorithm in the cement manufacturing industry (Khan & Sinha, 2022). Rasool et al. (2023) developed several key measures for digital supply chain performance. Other supply chain transformation topics include transportation cost optimization (Muntaka et al., 2023), the role of artificial intelligence for supply chain resilience (Dey et al., 2023), IoT-blockchain for efficient warehouse management (Kumar et al., 2023), the impact of knowledge management on digital supply chain transformation (Gagliardi et al., 2023), impact of digital transformation on supply chain relationship and collaboration dynamics (Hamann-Lohmer et al., 2023), role of structural social and human capital in supply chain transformation (Lang et al., 2022), factors and pathways to achieve supply chain resilience (Yin, 2023), impact of environmental dynamism on sustainable digital supply chain transformation (Sharma et al., 2022). Different industries are also examined for supply chain transformation issues. For example, Beaulieu and Bentahar (2021) discussed a roadmap to generate more benefits for digitalization of the healthcare supply chain. Saryatmo and Sukhotu (2021) examined the digital supply chain performance in the food and beverage industry in Indonesia.

1.2 Inventory cost control

Inventory is considered to be one of the most critical parts of any company and it needs to be correctly, efficiently and accurately managed (Govindasamy et al., 2022). On the one hand, companies must fully utilize the advantages of inventory to improve service quality and customer satisfaction. On the other hand, they must strictly manage and control inventory costs. Inventory cost consists of four main categories: inventory acquisition cost (procurement cost, ordering cost, and preparation cost), inventory holding cost (capital cost, inventory service cost, storage cost, and inventory risk cost), inventory out-of-stock cost (shortage cost and replenishment cost), and inventory in transit cost (inventory capital cost, inventory service cost, and inventory risk cost in transit).

Designing and operating a cost control system with spare parts as the main inventory is a complex task because the system needs to consider many influencing factors simultaneously, such as demand quantity, criticality, product failure rate, value, importance, procurement cost, production cost, replenishment period, and so on. According to Bacchetti and Saccani (2012), cost control activities with spare parts as the primary inventory should include three aspects: spare parts classification, demand forecasting, and inventory management. Inventory management is the top priority, while classification and demand forecasting can be considered supporting activities. Boylan and Syntetos (2010) argue that spare parts classification and demand forecasting should be linked to the inventory management policy of companies

and suggest that companies should organize inventory cost control activities in a closed loop. In recent years, the role of ABC classification in inventory cost control has been discussed. For example, Hanafi et al. (2019) argue that ABC classification can help the realization of green inventory control by minimizing total inventory cost. Eraslan and İÇ (2020) developed an improved decision support system (IDSS) which is a software to obtain more accurate and fast ABC classification for inventory control. Other technologies were also adopted in ABC classification such as the use of acceptability analysis (Li et al., 2019), Pareto's principle (Kheybari et al., 2019), Gaussian mixture model (Zowid et al., 2019), multi-attribute fuzzy method (Yung et al., 2021), stochastic data envelopment analysis approach (Tavassoli & Farzipoor Saen, 2022), extended R-model, SVM and Lorenz curve (Sarkar, 2023).

Companies must first classify and manage spare parts to better control inventory costs. Based on this, companies need to adjust different demand planning and forecasting models. Then, according to the different demands for spare parts and the degree of cooperation between the internal business model and the external supply chain, companies need to establish a targeted inventory management method and finally form an inventory cost control system that can support their operations.

As the internal supply chain is a main part of the whole supply chain and in consideration of the unique inventory cost control challenges of SMEs in supply chain transformation, this paper selects a small and medium-sized distributor of home appliances in Hunan Province, China, as a case study to discuss and analyze the company's operating model at the initial stage of supply chain transformation and to optimize its inventory cost control system for internal supply chain management.

Although many issues have been discussed on digital supply chain and supply chain transformation, much research is on enablers, strategies, and impact of different digital technologies and factors on supply chain transformation. Little research has been done on the impact of digital supply chain transformation on a single SME from an internal chain perspective. In this research, we will study optimization of inventory cost control for the SME in the context of digital supply chain transformation. For this purpose, an integrated approach was developed, which includes an improved ABC inventory classification method, spare parts demand forecasting, and an adapted inventory management method. We believe the integrated approach will be able to optimize inventory cost control more effectively and efficiently.

2. Case introduction

2.1 Company profile

Company Z, located in Hunan Province, China, was established in 2006 as an SME home appliance distributor. The company has exclusive distribution rights for many brands in the region. It is located in the middle of the home appliance supply chain, connecting upward to home appliance supply groups and downward to home appliance retailers. Through field research, we learned that most home appliance companies had implemented channel-deepening transformation to "continuously improve channel efficiency and transform retail service capabilities." In order to follow the principle of separate operation of logistics and trade, many home appliance companies re-planned the functions of inventory storage, logistics management, marketing, and after-sales service in each city of the province, breaking through the original administrative division, gradually eliminating the "hoarding mechanism" of distributors, and sending home appliances directly to retailers. In addition, home appliance companies take the original warehouse in the province as the logistics and shipping center of the products, build their own logistics departments or rely on third-party carriers, gradually forming a modern logistics and distribution system with independent operation and perfect management. As a result, all the home appliances of Company Z have been transferred to home appliance companies for management.

Under the transformation trend of the supply chain and the fierce competition among home appliance distributors, Company Z needs to quickly define its positioning, continuously push new value-added category services, optimize inventory cost control, enhance and improve channel operation efficiency, and contribute to the innovation and reform of the core companies of the supply chain.

2.2 Supply chain transformation impact on inventory costs

According to the management decision, Company Z has entered into a strategic cooperation

agreement with home appliance companies to acquire businesses such as regional home appliance after-sales services. This means that Company Z's business model would be changed from a distribution nature to a service nature, and its main inventory business would be changed from home appliances to various spare parts needed for after-sales services. This is a reconfigured strategic upgrade and renewal.

After-sales service means that Company Z meets home appliance users' subsequent various service needs after the retailer sells the product. The service's main contents include inspection, repair, maintenance, and replacement of home appliances. A high level of after-sales service reflects the competitive advantage of home appliance companies. Therefore, after-sales service by home appliance companies aims to improve customer satisfaction, satisfy individual needs, and obtain maximum benefits. This paper studies the impact of supply chain transformation on Company Z's inventory cost. A comparison of Company Z's inventory cost focus before and after supply chain transformation is shown in Tab. 1.

Tab. 1: A comparison of Company Z's inventory cost focus before and after supply chain transformation

Inventory cost items	Before supply chain transformation	After supply chain transformation
Main inventory	Home appliances	Spare parts
Inventory type	Less variety	More variety
Main service targets	Home appliance retailers	Home appliance users
Warehouse area	Large area	Small area
Demand forecast basis	Consumer demand	Sales volume and failure rate
Classification indicators	Turnover rate, value, demand, and profitability	Criticality, replenishment period, and suppliers
Inventory cost management focus	Stockholding cost	Inventory acquisition cost; on-transit stockholding cost

Source: own

Based on the above comparison, Company Z should start from the organizational structure and business process reorganization, integrate the regional logistics and distribution system, optimize the spare parts storage structure, continuously reduce the inventory cost by itself, and improve the after-sales service satisfaction of home appliance users.

3. Optimization of inventory cost control system

The inventory management of spare parts differs from that of ordinary finished products. Suppose Company Z directly applies the original inventory management system to spare parts management. In that case, it may lead to the problem of spare parts inventory hoarding or shortage. It may also cause economic losses such as capital occupation or service stoppage, directly affecting the company's economic benefits (Qu & Zhang, 2006). Therefore, Company Z needs to strengthen inventory cost control according to the characteristics of spare parts required for after-sales service.

Based on the analysis of the literature review, this paper proposes a set of inventory cost control methods applicable to internal supply chain management, taking into account the actual operating situation of the supply chain transformation of Company Z.

3.1 Implementing an improved ABC classification method

In order to implement an improved ABC classification method, there are a few steps to follow, as discussed below.

(1) Establishing a two-stage model for spare parts

According to the two-stage classification model, this paper classifies spare parts into three categories in the first stage: fast-moving spare parts,

Tab. 2: Characteristics of the first stage of spare parts classification

Classification	Demand	Purchasing volume	Restocking period	Scrapping ratio	Prediction difficulty
Fast-flowing	High	High	Short	Low	Low
Slow-flowing	Low	Low	Long	High	High

Source: own

slow-moving spare parts, and infrequent spare parts. Infrequent spare parts are spare parts with zero consumption value in one year for the company, and the spare parts are still essential to support the company's operation; slow-flowing spare parts are those with an uncertain demand rate of less than 1 per year; fast-flowing spare parts are those with an uncertain demand rate of more than 1 per year (Zhao et al., 2004). According to the actual situation of Company Z, this paper summarizes the characteristics of fast-moving and slow-moving spare parts (Tab. 2).

In the second stage of the classification model, this paper adopts the improved ABC classification method to classify the spare parts of Company Z. The method is based on the basic

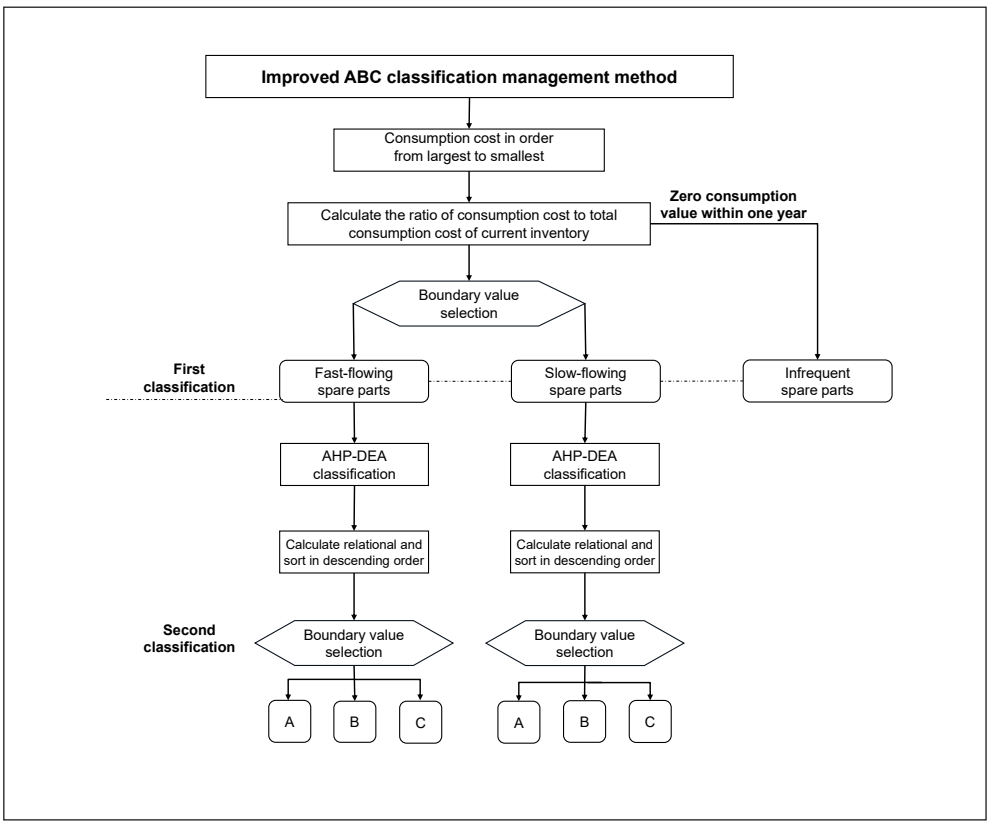

Fig. 1: The improved ABC classification management method

Source: own

logic of the ABC classification method, combines analytic hierarchy process (AHP) with super efficiency data envelopment analysis (SE-DEA), solves the total weight of spare parts by grey relational analysis (GRA), and then sorts and classifies the spare parts, classifying the spare parts with the top 20%, middle 30% and bottom 50% correlation into three categories A, B and C (Fig. 1).

Compared with the traditional ABC classification method, which only considers a single factor, and the AHP-ABC classification method, which is highly influenced by subjective factors, the classification results of the improved ABC classification management method are more comprehensive, scientific, and reasonable, which is more helpful for Company Z's spare parts management and cost control.

(2) Establishing AHP-ABC classification

The classification process of fast-flowing spare parts and slow-flowing spare parts is the same. Due to the limited space, the analysis in this paper only takes fast-flowing spare parts as an example. However, the shortage cost of slow-flowing spare parts is generally higher than the inventory cost and storage cost, and its related index weights should be slightly different from those of fast-flowing spare parts. According to the actual operation situation of Company Z, this paper selects six classification indicators, namely, key factor (KF), replenishment period (RP), consumption cost (CC), shortage cost (SC), inventory cost (IC), and the number of suppliers (NS).

In a word, the criticality factor refers to the importance of spare parts to the company's after-sales service. The smaller the criticality factor of spare parts, the greater the impact on business operations and the more attention companies should pay. The replenishment period is the interval between when the company places an order and when the spare parts arrive at the warehouse. Consumption cost is the company's total cost of spare parts consumption in each operation cycle. Shortage cost is the loss incurred by the company due to a shortage of spare parts supply. Inventory cost is the total cost incurred by the company to store spare parts.

Since Company Z started its transformation at the end of 2020, the spare parts data covers a short time, so in this research, only the data of the first half of 2021 of the company is used to speculate the annual demand rate of spare parts and evaluate their flow rate. In the paper, the data of 20 fast-moving spare parts were randomly selected and screened from the company's spare parts information system (Tab. 3).

Tab. 3: Information sheet for random sampling of fast-flowing spare parts – Part 1

No.	Material code	KF	RP	CC	SC	IC	NS
1	B2051-001-1227	5	15	10,120	13,730	104	6
2	B2062-001-MB35	8	10	7,440	12,200	130	4
3	B2069-001-0468	3	30	560	300	58	9
4	B2065-001-0462	2	10	640	592	23	16
5	B2055-001-0723	3	10	600	296	19	19
6	B2062-G01-DF01	7	45	900	3,470	43	7
7	B2062-001-MD01	9	30	1,600	2,980	76	6
8	B2003-001-1243	2	12	1,350	1,030	38	17
9	B2051-001-1105	5	15	11,160	15,380	94	11
10	B2055-001-0723	1	10	720	630	22	13
11	X2368-001-0017	1	30	700	430	24	16
12	X2421-201-0001	1	30	800	355	13	25
13	X2362-001-0631	7	30	4,200	86,360	73	3

Tab. 3: Information sheet for random sampling of fast-flowing spare parts – Part 2

No.	Material code	KF	RP	CC	SC	IC	NS
14	X2062-001-0095	6	20	12,800	16,385	195	4
15	X2061-001-0032	5	30	240	96	12	14
16	X2114-001-0099	3	15	520	538	36	6
17	X2113-001-0051	2	30	600	683	54	6
18	X2111-001-0067	1	15	10,800	14,294	42	15
19	X2067-001-0038	4	15	1,800	824	63	13
20	X2069-001-0211	2	20	840	1,035	32	8

Note: Key factors (KF) are scored by Company Z's employees. The unit of the replenishment period (RP) is days. Consumption costs (CC), shortage costs (SC), and inventory costs (IC) are in Yuan. Suppliers indicate the number of suppliers (NS).

Source: own

Tab. 4: Characteristics of the first stage spare parts classification

	KF	RP	CC	SC	IC	NS
KF	1	2	3	3	5	5
RP	1/2	1	3/2	3/2	5/2	5/2
CC	1/3	2/3	1	1	5/3	5/3
SC	1/3	2/3	1	1	5/3	5/3
IC	1/5	2/5	3/5	3/5	1	1
NS	1/5	2/5	3/5	3/5	1	1

Source: own

Tab. 5: Weight coefficients of the judgment matrix of classification indices

	KF	RP	CC	SC	IC	NS
Weight coefficients	0.389	0.195	0.130	0.130	0.078	0.078

Source: own

After soliciting the opinions of department heads and experts, we formed a judgment matrix and calculated its statistical weights based on the provisions of the comparative quantitative values between each key factor in the AHP criterion layer (Tabs. 4–5).

The maximum eigenvalue of the matrix is calculated to be max = 6.000.

$$CI = (\lambda_{\max} - N) \div (N - 1) = 0.000$$

The sixth-order stochastic consistency index is *RI* = 1.24.

$$R = CI \div RI = 0.000 < 0.01$$

Consistency check is passed.

(3) Combining SE-DEA to solve comprehensive weights

SE-DEA inherits all the advantages of the traditional DEA model and can effectively solve the problem of ranking the advantages and disadvantages of the traditional model. The calculation method of SE-DEA is shown in Equation (1).

$$\min [\theta - \varepsilon (\hat{e}^T s^- + \hat{e}^T s^+) \quad \text{S.t.} \begin{cases} \sum_{j=1, j\neq j_0}^{n} X_j \lambda_j + s^- = \theta X_0 \\ \sum_{j=1, j\neq j_0}^{n} Y \lambda_j + s^+ = y_0 \\ \lambda_j \geq 0, \ j = 1, 2, \ldots, n \\ s^+ \geq 0, s^- \geq 0 \end{cases} \quad (1)$$

Tab. 6: Schematic table of input and output indicators

Indicator	Number	Indicator name
Input indicators	*X*1	Key factor (KF)
	*X*2	Replenishment period (RP)
Output indicators	*Y*1	Consumption cost (CC)
	*Y*2	Shortage cost (SC)
	*Y*3	Inventory cost (IC)
	*Y*4	Number of suppliers (NS)

Source: own

where: θ – the super-efficiency value; $X_j = (x_{1j}, x_{2j}, \ldots, x_{nj})^T$ – the value of the input quantity; $Y_j = (y_{1j}, y_{2j}, \ldots, y_{nj})^T$ – the value of the output quantity; λ_j – the indicator weight; $s^- = (s^{1-}, s^{2-}, \ldots, s^{b-})^T$ and $s^+ = (s^{1+}, s^{2+}, \ldots, s^{b+})^T$ are the residual and slack variables, respectively.

Using SE-DEA, the two input indices and four output indices of the spare parts, as well as their residual and slack variables, can be found separately. On top of Equation (1), the preference coefficient β (β = 0.6) is introduced to solve for the combined weights, which are calculated as in Equation (2).

$$\alpha_i = \beta\omega + (1 - \beta)\, S_i \tag{2}$$

According to the basic principle of DEA, the indicators with a small impact on spare parts classification are set as input indicators, and those with a large impact are set as output indicators in this research. The input and output indicators are shown in Tab. 6.

By using DEA-SOLVER Pro5.0, this study solves the input and output indicators of 20 fast-flowing spare parts, as well as the vectors of residual and slack variables of the indicators, and finally solve the composite weights.

(4) Combining GRA for classification

Using GRA for classification, this study first determines the optimal set of classification indicators for spare parts management $Q_0 = (q_{01}, q_{02}, \ldots, q_{06})$, where q_{0j} ($j \in [1, n]$) denotes the optimal solution for the j^{th} indicator, and the optimal solution plays a boundary role in the classification indicators. It controls the min of the input indicators and the max of the output indicators so that the solution set matrix *G*1 can be inferred. Uniform regularization and normalization of *G*1 are performed to obtain the new matrix *G*, as shown in Equation (3).

$$G = \begin{pmatrix} q_{01}^* & \cdots & q_{06}^* \\ \vdots & \ddots & \vdots \\ q_{n1}^* & \cdots & q_{n6}^* \end{pmatrix} \tag{3}$$

where: *G* – the correlation coefficient matrix based on GRA.

The correlation coefficient ε_{ab} can be calculated for the b^{th} indicator in the a^{th} spare part and its corresponding optimal indicator, as in Equation (4).

$$\xi_i = E_i\, a_i^* = [\xi_{n1}, \xi_{n2}, \ldots, \xi_{n6}] \begin{bmatrix} a_1^* \\ \vdots \\ a_6^* \end{bmatrix} \tag{4}$$

ρ is the resolution ratio, taken as 0.5, and the relation coefficient matrix *E* composed of ε_{ab} can be solved. From the row vector E_i in the relation coefficient matrix *E* and the combined

Tab. 7: Results of grey relational analysis of spare parts

	KF	RP	CC	SC	IC	NS
Relatedness	0.562	0.578	0.545	0.553	0.553	0.594

Source: own

weight the correlation degree ξ_i of the i^{th} solution is calculated, which is Equation (5).

$$\varepsilon_{ab} = \frac{\min_i \min_j \left|q_{ij}^* - q_{0j}^*\right| + \rho \max_i \max_j \left|q_{ij}^* - q_{0j}^*\right|}{\left|q_{ab}^* - q_{0b}^*\right| + \rho \max_i \max_j \left|q_{ij}^* - q_{0j}^*\right|} \quad (5)$$

Rank ξ_i in descending order. A higher value of ξ_i means that the spare part is more important. The ranking results of the relatedness are classified according to the basic principles of ABC classification. The results of the GRA of spare parts are shown in Tab. 7.

(5) Results based on the improved ABC classification method

Based on the above analysis, this study can obtain the results of the traditional ABC classification method, the AHP-ABC classification method, and the improved ABC classification management method for 20 fast-flowing spare parts of Company Z (Tab. 8).

Different classification methods can lead to different results for the same batch of spare parts. For instance, under the ABC classification and the AHP-ABC classification, spare part 2 is classified as Class B, and spare parts 4 and 5 are classified as Class C. However, under the improved ABC classification, spare parts 2 and 5 are upgraded to Class A, and spare part 4 is upgraded to Class B. It is worth noting that spare part 14, which is classified as Class A under the ABC classification and Class B under the AHP-ABC classification, is unexpectedly downgraded to Class C under the improved ABC classification.

The improved ABC classification method considers the weight relationship between multiple indicators and reduces the influence

Tab. 8: Classification results

No.	Material code	ABC	AHP-ABC	Improved ABC
1	B2051-001-1227	A	B	B
2	B2062-001-MB35	B	B	A
3	B2069-001-0468	C	B	C
4	B2065-001-0462	C	C	B
5	B2055-001-0723	C	C	A
6	B2062-G01-DF01	C	A	C
7	B2062-001-MD01	B	A	B
8	B2003-001-1243	B	C	C
9	B2051-001-1105	A	B	A
10	B2055-001-0723	C	C	C
11	X2368-001-0017	C	C	C
12	X2421-201-0001	C	C	C
13	X2362-001-0631	B	A	B
14	X2062-001-0095	A	B	C
15	X2061-001-0032	C	B	B
16	X2114-001-0099	C	C	C
17	X2113-001-0051	C	C	C
18	X2111-001-0067	A	B	A
19	X2067-001-0038	B	C	B
20	X2069-001-0211	C	C	C

Source: own

of subjective factors in decision-making, so it has higher comprehensiveness, science, and rationality. Consequently, Company Z can analyze its inventory level by this method and achieve timely inventory warnings.

3.2 Setting up market demand forecasting plan

There are not many SMEs in China that can accurately calculate the demand for spare parts through material requirements planning (MRP). However, SMEs can use scientific forecasting methods and hire professional inventory planners to reduce operating costs, increase inventory turns, and improve inventory levels. To improve the accuracy of spare parts demand forecasting, the management of Company Z needs to abandon the empirical forecasting method. The company should adopt a more scientific forecasting method for different spare parts according to the demand pattern and characteristics. Based on the improved ABC classification management method results, this study proposes a feasible demand forecasting model for Company Z's spare parts (Fig. 2).

Using the data of fast-flowing spare parts as an example, this study measures and analyses the demand forecasting method for spare parts of Company Z.

(1) Class A for fast-flowing spare parts

Class A spare parts for fast-moving spare parts of Company Z are characterized by high importance and value. The demand for this type of spare parts is moderate, continuous, and the demand trend fluctuates up and down in some benchmarks.

In this study, the single exponential smoothing method is selected for demand forecasting of Class A spare parts, as in Equation (6). This method applies to forecasting demand without an apparent change trend.

$$S_t = \alpha \times Y_t + (1 - \alpha) \times S_{t-1} \tag{6}$$

where: S_t – the exponentially smoothed value at time t; Y_t – the actual value at time t; S_{t-1} – the exponentially smoothed value at time $t - 1$; α – the exponential smoothing constant.

The predicted value of the single exponential smoothing is calculated as in Equation (7).

$$Y_{t+1}^{*} = \alpha \times Y_t + (1 - \alpha) \times Y_t^{*} \tag{7}$$

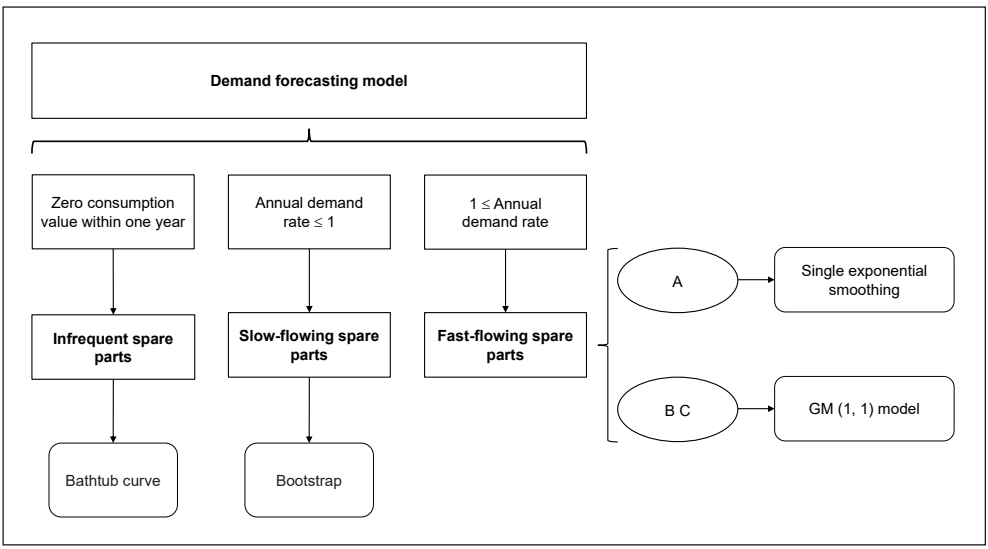

Fig. 2: Spare parts demand forecasting model based on improved ABC classification

Source: own

Tab. 9: Historical data observation for fast-flowing spare parts Class A

Month	January	February	March	April	May	June
Observation	5	4	5	7	6	4

Source: own

where: Y^*_{t+1} – the predicted value for time $t+1$, which is the exponentially smoothed value for time t; Y^*_{t+1} – the actual value for time t; Y^*_t – the predicted value for time t, which is the exponentially smoothed value for the previous period.

Taking spare part 5 as an example, this study forecasts the demand for the first half of 2021. The historical data observations for spare part 5 are shown in Tab. 9.

Taking the smoothing index α as 0.1–0.9, the mean square error (MSE) of single exponential smoothing is obtained (Tab. 10).

Based on this, the mean square error is minimized when α = 0.1, and its spare parts prediction value, is shown in Tab. 11.

The smaller the standard error, the closer it is to the actual value. The standard error is minimized when α = 0.1 by applying the trial algorithm. Therefore, the forecast of Class A spare parts of Company Z can be made according to the solution of spare part 5.

(2) Class B and Class C for fast-flowing spare parts

Company Z's fast-moving spare parts, Class B and Class C, are mostly general spare parts with high consumption. The relevant sample data of the company is small for the time being, and the GM (1, 1) grey prediction model has the advantages of collecting few samples. Samples do not need to show regular distribution, small computational workload, and high accuracy, which can be used for short-medium and long-term prediction. The operational steps of the GM (1, 1) model are specified as follows.

Suppose there are n observations of the original series $X^{(0)}$, which is:
$X^{(0)} = \{X^{(0)}(1), X^{(0)}(2), ..., X^{(0)}(n)\}$, the new series $X = \{X(1), X(2), ..., X(n)\}$ is obtained by cumulative summation. The differential equation of the GM (1, 1) model is as follows.

$$\mathrm{d}X \div \mathrm{d}t + \alpha X^{(1)} = \beta \tag{8}$$

Tab. 10: List of MSE

	α								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MSE	1.269	1.374	1.481	1.585	1.680	1.759	1.817	1.849	1.854

Source: own

Tab. 11: Demand forecast table for fast-flowing spare parts Class A

	January	February	March	April	May	June
Observation	5	4	5	7	6	4
Predicted value	5	5	5	5	5	5
Error	0	1	0	2	1	1
Percentage (%)	0.00	25.00	0.00	28.57	16.67	25.00

Source: own

where: α – the development of the grey number; β – the endogenous control grey number.

Let $A = [\alpha\ \beta]^T$ and use the least-squares method to find $A = (B^TB)^{-1}B^TY$.

$$B = \begin{bmatrix} -\frac{1}{2}\{X^{(1)}(1) + X^{(1)}(2)\} & \cdots & 1 \\ \vdots & \ddots & \vdots \\ -\frac{1}{2}\{X^{(1)}(n-1) + X^{(1)}(n)\} & \cdots & 1 \end{bmatrix} \quad (9)$$

$$Y = [X^{(0)}(2), X^{(0)}(3), \ldots, X^{(0)}(n)]^T \quad (10)$$

By substituting the required parameter values into the differential equation, Equation (11) is obtained.

$$X^{(1)}(i+1) = \left[X^{(1)}(1) - \frac{\beta}{\alpha}\right]e^{-\alpha t} + \frac{\beta}{\alpha} \quad (11)$$

The above calculation only yields one accumulation. The final predicted value of the spare parts can be obtained only through the recursive generation of data $X^{(1)}(i+1)$.

On this basis, the demand forecast is carried out for spare part 4 of Class B and spare part 11 of Class C. The forecasted results are shown in Tab. 12.

Under this model, the error rate of forecasting Class B and Class C spare parts is less than 0.1, which means the accuracy is more than 90%. This indicates that it is feasible to use the GM (1, 1) model to forecast the demand for fast-flowing Class B and Class C spare parts for Company Z.

3.3 Adopting an adapted inventory management method

Inventory management methods depend mainly on Company Z's inventory check cycle, order time, and procurement quantities. The main influencing factors are the consumption characteristics and classification of spare parts. For example, for inventory with high key factors, long replenishment cycles, high shortage costs, and few sources of supply, Company Z should not only order in advance but also maintain safety stocks. However, high purchase quantities can lead to excessive inventory levels. To some extent, this can improve Company Z's service levels, but it can also significantly increase inventory costs. Therefore, it is important for the company to balance the relationship between service levels and inventory costs. The analysis in this study continues to focus on fast-moving parts.

(1) Inventory management of infrequent spare parts

The infrequent use of spare parts does not mean that they do not support Company Z's actual operations, but rather that their demand and frequency of use are extremely low. In addition, the shortage cost of infrequently used spare parts may be high, or such parts may only serve the company internally, making it "necessary" for the company to continue to stock them for emergencies. The inventory management method for infrequent spare parts is shown in Fig. 3. For the rare spare parts located in the empty area of Fig. 3, Company Z should choose the order point

Tab. 12: Demand forecast table for fast-flowing spare parts Class B and Class C

Spare part		January	February	March	April	May	June
4	Observation	12	15	18	22	24	28
	Predicted value	12	16	18	21	24	28
	Error	0	1	0	1	0	0
	Percentage (%)	0.00	3.56	0.11	4.99	1.03	0.45
11	Observation	8	9	10	11	13	14
	Predicted value	8	9	11	12	13	15
	Error	0	0	1	1	0	1
	Percentage (%)	0.00	4.72	5.63	7.63	2.08	6.24

Source: own

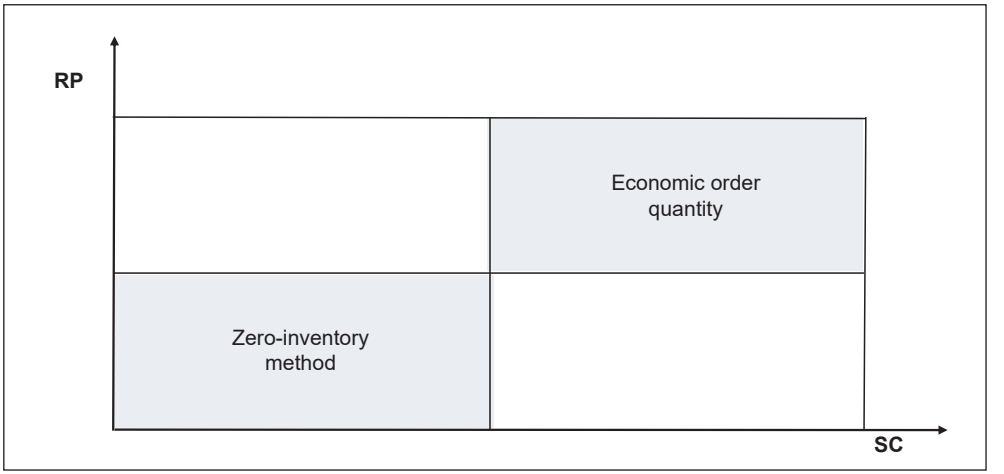

Fig. 3: **Inventory management methods for infrequent spare parts**

Source: own

method or the zero inventory method according to the actual situation.

Company Z can use the zero-inventory method for infrequent spare parts with relatively short replenishment lead times and relatively low shortage costs, which means that the company does not stock such spare parts and purchases them from suppliers when needed.

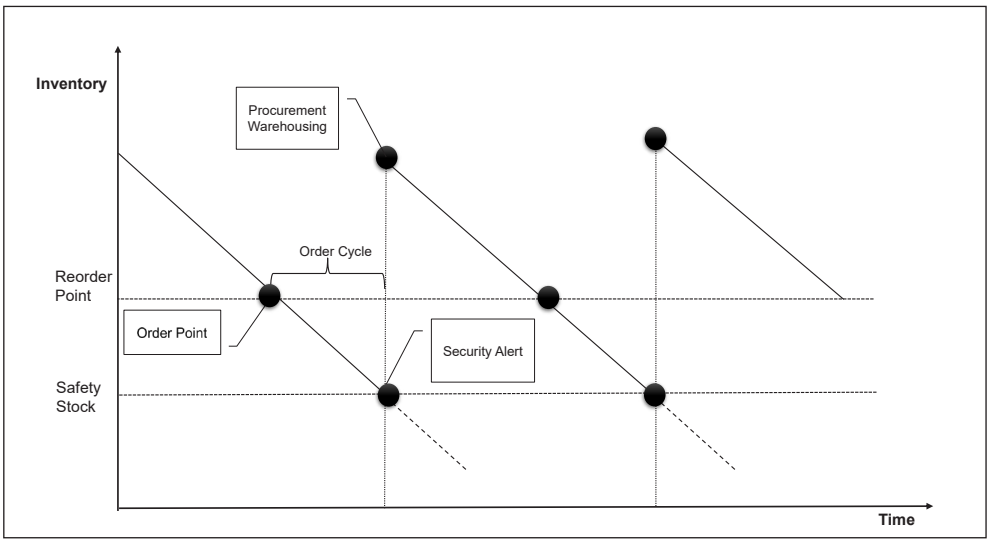

Fig. 4: **Order point method (safety stock method) for infrequent spare parts**

Source: own

Meanwhile, Company Z should use the order point method for the infrequent spare parts with long replenishment lead times and high shortage costs, which means the company maintains a safety stock for such spare parts, as shown in Fig. 4.

The purpose of safety stock at Company Z is to provide a buffer against the effects of uncertainties, such as changes in demand or delays in delivery. The level of safety stock is influenced by three factors: the uncertainty of demand for spare parts, the uncertainty of supply, and the service level (availability rate requirement). For Company Z, safety stock is also a cost of inventory that cannot be ignored. For this reason, Company Z cannot make a rough estimate of spare parts demand based only on market experience. The company should quantify the influencing factors as much as possible, based on historical data and mathematical and statistical methods, so that the order time is as close as possible to the demand time and the purchased quantity is as close as possible to the demand quantity. The company must ensure its inventory adequacy and reduce supply instability.

(2) Inventory management of slow-flowing spare parts

Slow-moving spare parts still occupy an important position in the after-sales service work of Company Z. They are characterized by high criticality, high versatility, low demand, long replenishment period, high shortage cost, high scrap rate, and tricky demand forecast. In response to these characteristics, Company Z can use the periodic inventory method, which means that spare parts are inventoried at regular intervals, and the amount of replenishment depends on the quantity in inventory after the inventory is taken. It is also worth noting that slow-moving items have a low inventory turnover rate, and management is focused on minimizing inventory. Therefore, Company Z needs to determine the order point and replenishment quantity for slow-moving items.

Slow-moving Class A spare parts are critical to Company Z's daily operations. Once the spare parts are missing, it will lead to a reduction in the company's after-sales service level and customer satisfaction. To ensure sufficient spare parts quantity, this study adopts ($S-1$, S) inventory management method. In order to ensure the continuous supply of spare parts, the ($S-1$, S) inventory management method requires Company Z to immediately replenish one spare part for every one consumed. In addition, the company's spare parts planners must regularly check the spare parts and provide an accurate picture of the inventory and storage status of the spare parts. The planners also need to record various spare parts issues and make a simple forecast of the expected useful life of remaining spare parts and market demand to determine their ordering points.

Compared to slow-moving spare parts, Class A, Class B, and Class C spare parts have lower criticality, shorter replenishment lead times, lower shortage costs, lower demand, and lower total value. By devoting too much management effort to these types of spare parts, Company Z cannot achieve more economic benefits and has limited cost savings. As a result, the spare parts inventory management in Company Z may be rough. This study considers the (t, S) inventory management method appropriate for Company Z. This method requires Company Z to inspect the spare parts at a fixed inspection interval t before ordering. And the company's order quantity at each time is the difference between the maximum spare parts inventory and the actual inventory. Adopting this method for slow-flowing Class B and Class C spare parts helps spare parts planners to focus more on managing Class A and fast-flowing spare parts to achieve accurate management. Company Z should avoid frequent reconciliation of such spare parts to reduce operational difficulties and workload. In addition, Company Z can manage logistics and transportation through order integration to save time and costs, make it easier for suppliers to arrange production storage and logistics distribution, and reduce supply uncertainty.

(3) Inventory management of fast-flowing spare parts

Company Z's most important spare parts are fast-moving spare parts, which are characterized by stable demand, rapid consumption, short procurement time, high capital consumption, and low demand volatility. Continuous inventory is a common method for managing fast-moving spare parts, which enables a quick response through accurate detection and potential shortage problems. When the quantity of spare parts falls to a certain level, Company Z should order them immediately to restore the inventory

to an acceptable level. Company Z uses continuous inventory to maintain the inventory at a reduced level, but it also incurs some labor costs. Therefore, this method is only suitable for spare parts that are consumed and circulated at a high rate.

Fast-moving Class A spare parts are the most important spare parts for Company Z. The company not only needs to minimize the shortage probability of spare parts but also needs to reduce its inventory level. For this reason, this study considers that

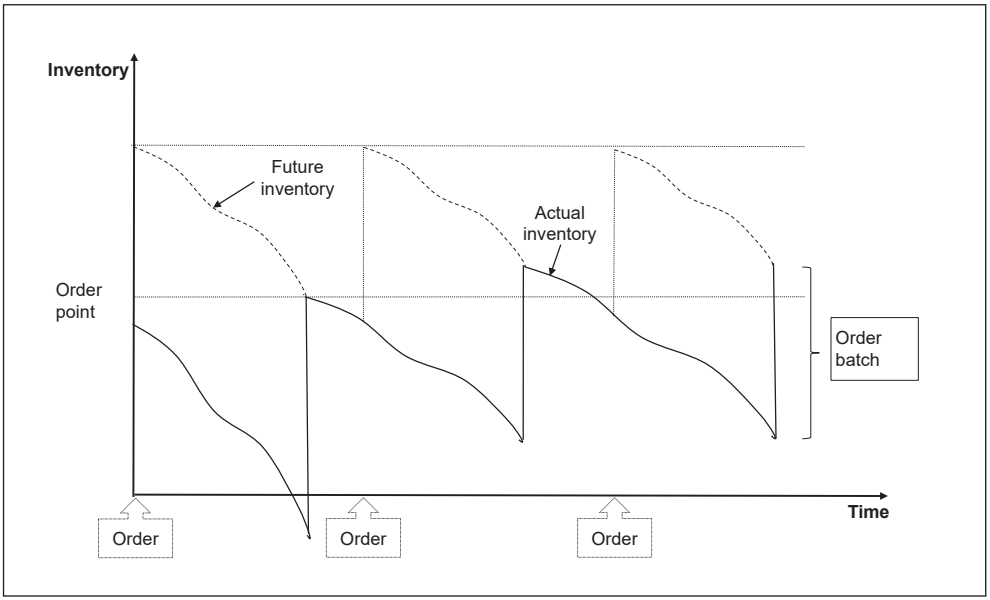

Fig. 5: **(*R, Q*) Inventory management method for fast-flowing spare parts Class A**

Source: own

the (*R*, *Q*) inventory management method can better manage the fast-moving Class A spare parts (Fig. 5).

Thus, it is clear that the reorder point of the (*R*, *Q*) management method is *R*. Each order quantity *Q* is precisely calculated, and if the inventory quantity is found to be less than *R* after a continuous inventory check, an order quantity *Q* is immediately placed. In addition, Company Z must implement other control measures for fast-moving Class A spare parts, such as detailed and complete records of spare parts receipt, issue, and inventory, detailed procurement plans, and strict logistics control. At the same time, Company Z must establish a good cooperative relationship with spare parts suppliers to ensure the timeliness and stability of their supply, as well as the quality and quantity of spare parts. Fast-moving Class A spare parts are characterized by relatively high demand and value, high shortage cost, and long replenishment time, which have a significant impact on the company's warehouse logistics. Company Z should ensure the procurement quantity and safety stock of such spare parts to some extent. However, the company should also try to reduce the occupied area of the warehouse to save inventory carrying costs and pay attention to the consumption of spare parts to prevent shortages.

Fast-moving Class B and Class C spare parts are of secondary importance in the spare parts management activities of Company Z. These spare parts are characterized by high demand and short replenishment time, and the service level requirement is not as high

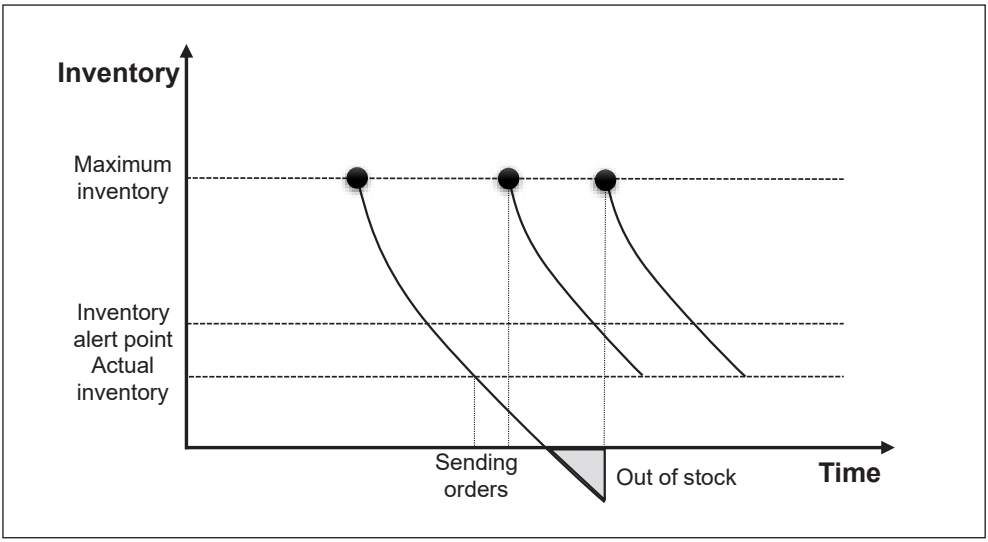

Fig. 6: **(*s*, *S*) Inventory management method for fast-flowing spare parts Class B and Class C**

Source: own

as that of Class A. For this reason, this study suggests that Company Z may choose the (*s*, *S*) method for the management and control of fast-moving Class B and Class C spare parts (Fig. 6).

It can be seen that the continuous inventory cycle for fast-moving Class B and Class C spare parts can be slightly longer than for Class A. After each inventory check, the inventory is replenished to the maximum inventory level *S* when the inventory falls below the order points. Fast-moving Class B and Class C spare parts are generally not very valuable and have a relatively small capital footprint. Company Z can set a maximum inventory level for this type of spare part to minimize management efforts.

Conclusions

Although reducing the inventory level can reduce the inventory cost of a company to a certain extent, it may lead to problems such as the increased risk of shortage, frequent emergency procurement, lower service level, and lower customer satisfaction, and the inventory cost of the company will increase rather than decrease. Therefore, establishing a scientific and reasonable inventory cost control system is a necessary condition for the healthy operation of the company.

For SMEs that are or will be in the supply chain transformation phase, it is important to leverage the supply chain externally to manage inventory and internally to optimize the inventory cost control system. Compared to large companies, SMEs are in a relatively disadvantaged and passive position in terms of capital size, technical resources, human resources, supply chain influence, voice, and decision-making power. However, this does not mean that SMEs are “helpless” when it comes to inventory. On the contrary, SMEs can proactively respond to the supply chain transformation, integrate resources and change their mindset in a shorter time to optimize their inventory cost control system. As the internal supply chain is considered to be a main part in supply chain transformation, this study focuses on internal supply chain management of the case company in order to propose and validate an intergrated approach for inventory cost control.

For the internal supply chain management of various spare parts required for the operation of the case company, this study proposes to first classify spare parts into three categories:

fast-flowing, slow-flowing, and infrequent, and then handle them according to the basic principles of the improved ABC inventory classification method. Then the improved ABC inventory classification method integrates three other methods, namely AHP, SE-DEA, and GRA, and considers the weight relationship among multiple indicators to reduce the influence of subjective factors in decision-making. As a result, the improved ABC inventory classification method is more comprehensive and precise; secondly, according to the different classification results of spare parts, companies are suggested to set up different demand forecasting plans to improve the accuracy of demand forecasting; furthermore, to determine the appropriate ordering point and procurement quantity, companies also need to specify different inventory management methods based on different classifications of spare parts. The integrated approach for inventory cost control is validated using the case study to prove that it is efficient and effective. A number of suggestions are also discussed to further optimize inventory cost control for SMEs in supply chain transformation.

The issues covered in this study are only a part of the inventory cost control problems of the case company. In the future other situations and factors need to be considered, such as external supply chain management cooperation, which needs to be explored in depth by future practitioners and academics.

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Determinants of the impact of ESG policy and corporate governance on employee rights

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Abstract: *To comply with international development trends in recent years, Taiwanese government agencies have formulated environmental, social, and governance (ESG) legal policies and strengthened publicity for listed firms to prepare sustainability reports. Government agencies are trying to use ESG legal policies to gradually guide firms to take environmental, social, and governance measures and move toward sustainable operations. However, employee rights were easier for firms to ignore in the past, so paying attention to the correlation between employee rights and organizational governance is necessary. This paper aims to analyze the relationship between the organizational governance and employee turnover rate of Taiwanese food firms in the ten years from 2011 to 2021 through a panel regression model. The results show that there is a U-shaped relationship between board size and employee turnover. There is an inverted U-shaped relationship between the development of major shareholders' shareholding and the strength of human resources. The research results show that organizational governance is significantly related to employee turnover. Finally, this paper believes that paying attention to human resources will contribute to the sustainable development of enterprises. Therefore, in terms of organizational governance policies, although government agencies have formulated relevant reference standards, firms should have functions more conducive to developing human resource measures. These functions include utilizing the guiding energy of the board of directors functions, and shareholding structure design, which will further help the stable development of human resources. Firms need high-quality human resources to make breakthroughs in technology or the market. Therefore, when firms cultivate high-quality human resources, they not only rely on employee welfare conditions but consider long-term organizational governance and human resource development as necessary planning conditions. These factors will drive firms to have the ability to break through the status quo, value all stakeholders, and create an attitude toward sustainable business development.*

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Introduction

In recent years, firms' practice of environmental, social, and governance (ESG) has attracted global attention. Pursuing employee turnover is indeed an essential key factor for firms to pursue sustainable development. Employees are essential assets of the firm. Employees and the firm have an employment contract, and

each has rights and obligations. In addition to workability, the firm's expectations for employees include work attitudes such as loyalty. However, belief does not only come from salary and welfare conditions. Firms must treat employees well and gain their trust in exchange for commitment and reduce employee turnover. If the firm cannot meet these needs, talent will flow, increasing the firm's recruitment and training costs and causing problems such as the inability to accumulate experience. Therefore, in addition to complying with labor protection and welfare measures stipulated in national laws and regulations, firms should also respect the rights of employees.

In recent years, corporate social responsibility has gradually received international attention, including non-financial management elements such as environmental management, employee care, corporate governance, supplier management, and risk management in social welfare activities and corporate operations. Therefore, Taiwan's competent authorities issued the "Corporate Social Responsibility Best Practice Principles for Listed Firms" in 2022 to guide Taiwan's listed firms in practicing corporate social responsibilities and implementing honest operations. In 2021, the competent authority issued the "Taiwan Stock Exchange Corporation Rules Governing the Preparation and Filing of Sustainability Reports by Listed Firms," requiring the food industry and catering revenue to account for more than 50% of their total operating revenue, the financial sector, and the chemical industry. The "Sustainable Development Best Practice Principles for Listed Firms" was released in 2022 (Taiwan Stock Exchange, 2021, 2022a, 2022b).

Regarding legal policy, Taiwan's competent authorities have strengthened firms' standards for caring for employees' rights through corporate sustainable development measures. At present, most legal policies are based on soft law. The competent authorities believe that if challenging, complex rules are directly applied to firms, it may lead to the risk of infringing on the firm's freedom of operation and causing a rebound effect on the firm. Therefore, in addition to regulating mandatory disclosure in some industries, the current legal policy encourages regulations for other industries. Thus, the corporate sustainability report discloses the firm's equal human resources structure, employee benefits, career development and training, occupational health and safety, occupational safety system, to enhance the transparency of employee relationship information.

This paper suggests that firms should engage in higher-standard employee care measures and even voluntarily incorporate employee rights and welfare measures into the firm's legal policies and guidelines. We believe that it will have a synergistic positive impact on the firm. On the one hand, the firm has taken a voluntary attitude and higher standards to formulate its ESG legal policy. On the other hand, it creates high trust in the corporate image among all stakeholders.

In terms of management implications, ESG policies and corporate governance have an impact on strengthening employee rights, especially on employee turnover. We believe the firm has robust R&D technology, financial capabilities, and other competitiveness. Still, a brain drain crisis will affect the firm's competitiveness if it cannot take care of employee rights. Therefore, implementing ESG policies will help make the firm more competitive, generate more operational synergies, and strengthen employee centripetal force, in addition, regarding the design of corporate governance measures, such as the size of the board of directors, the shareholding attitude of major shareholders, and the soundness of corporate governance. Management should not only consider the firm's profit factors but also care about the rights of employees. It also helps the firm retain talents and have solid human resources.

De Lucia et al. (2020) argue that growing awareness of climate change and human capital issues are turning firms beyond traditional financial gains. In particular, changes in global society's behavior towards sustainability issues and the availability of ESG indicators attract investors to make socially responsible investment decisions. In the past, firms only paid attention to corporate profits and seemed to care little about employee turnover. Therefore, many firms cannot effectively develop the value of human resources. Lo and Liao (2021) guide on strengthening human resource management, rather than short-term financial performance, to help century-old businesses achieve sustainable development. In Taiwan, in recent years, the public has been very concerned about the corporate social responsibility attitude of the food firms. Due to the high mobility of human resources in the food firms, how

to use the corporate governance mechanism to help the employee turnover is indeed an essential part of the food firms.

In particular, organizational governance significantly impacts corporate management policies. However, in the past, the literature has attached great importance to the relationship between business performance and equity structure. Singh et al. (2018) showed that ownership structure significantly impacts organizational performance. Chiu et al. (2021) showed that turnover rate had a significantly inverted U-curve relationship with innovation and suggested that firms should find a balanced value for their turnover rate to get the highest return on innovation. This paper focuses on organizational governance and human resource stability, exploring the critical factors of human resource stability in food firms. It further explores the nonlinear relationship between organizational governance and human resource stability. Grossman (2010) examines the impact of corporate governance on organizational employment stability and shows that firms whose boards consist of a more significant proportion of independent or outside directors have lower levels of overall employment stability. Harsch and Festing (2020) explain that talent management differs in terms of size, age, structure, industry, and ownership. As a result, they identified different types of dynamic talent management capabilities promoting organizational agility to various extents.

The search for a relationship between ESG criteria and corporate management is more and more important. ESG is of great significance to the development of food firms, especially since the shareholding structure of food firms faces many challenges because the shareholding structure of the food firms may focus on the creation of firm value and return to shareholders. However, considering the importance of R&D innovation policies in food firms, human resources are an essential factor that cannot be ignored.

Han and Kim (2021) find that firms with high employment stability maintain significant cash holdings for R&D intensive firms and firms with high firm-specific human capital. These results are consistent with a theory predicting that firms hold cash to indicate the credibility of their employment policies concerning job security. This paper adopts the dynamic panel model method to explore the relationship between human resources and organizational governance in food firms from 2011 to 2021. It examines the impact of human resources on R&D innovation policies. Our findings suggest that human resource stability exhibits a U-shaped relationship with board organization. However, there is an inverted U-shaped relationship between the strength of human resources and the shareholding of significant shareholders. In addition, there is a negative relationship between employee turnover and R&D innovation. Wang and Yan (2022) show that employee quality has positive externalities on future financial performance and firm value. Hrazdil et al. (2021) find that firms strategically engage in CSR practices to retain employees. Dore (2005) investigates the reformers of corporate governance in Japan and Germany; their purport has more favoring shareholders at the expense of employees. Cho (2005) shows that corporate governance provides an appropriate starting point for developing policies to build an efficient human resource management system.

Abe (2002) focuses on the influence of corporate governance structures on employment adjustment in Japanese firms and indicates that corporate governance structures affect employment adjustment, especially the presence of large stockholders slows down the speed of employment adjustment. Chen and Kao (2022) showed that firms with more women directors tend to implement less downsizing and such a talent-retaining strategy benefits firm performance. Abe and Shimizutani (2007) examine how board ownership structures reduce labor costs when firms face excess employment and find that outside directors are more inclined to implement layoffs or early retirement. Muthusamy et al. (2011) argue the role employees are supposed to play in firm governance and employee participation in corporate decision-making augments firm performance and limits corporate excesses.

Croucher and Miles (2010) question whether current corporate governance initiatives are adequate to promote employee interests and conclude that more stringent regulation is required for firm governance. Bernacchio (2015) considers employee programs to be a means of implementing a practice-based corporate governance model. Villiers (2021) highlights that corporate governance has a role in ensuring workers' needs are met; there is tension between the goals of any reforms in corporate

governance and worker. The article examines the changes in ownership and corporate governance that have affected industrial relations systems and findings that institutional no-stability in industrial relations. Roberts and van den Steen (2001) discuss that the attractiveness of shareholder-dominated governance depends on the extent to which workers' interests are protected by outside employment options. Michie and Oughton (2002) argue that the development of corporate governance and legal structures facilitates the combination of employee ownership. The article of Kocmanová and Šimberová (2014) contributes to the effort of ESG to measure corporate sustainability. Campbell et al.'s (2012) findings show managers should focus on tailoring compensation packages to help high-performing individuals in knowledge-intensive settings.

Werner et al. (2005) show that there is significant pay sensitivity between employees with the ownership structures. John and Senbet (1998) argue that the independence of the members of the board size determines the effectiveness of the board of directors. Fama and Jensen (1983) pointed out that the board of directors is not only an important firm's managerial mechanism, but the board will also affect the firm's effectiveness in terms of R&D innovation. Han and Kim (2020) find that employment stability is positively correlated with innovation output, and the findings suggest that employment stability enhances employee incentives to innovate by providing tolerance for failure. Based on a job demand-resource model, Montani et al. (2020) argue that this indirect relationship exhibits an inverted U-shaped pattern, where moderate workloads are most likely to benefit innovative behaviors. The related literature for this paper is listed in Tab. 1.

This paper organizes relevant literature in Tab. 1. From the literature, we sort out the core discussion aspects, including financial policy, ownership of corporate governance, and R&D innovation. We expected the possible impact on employee turnover by discussing these aspects in the past literature.

1. Theoretical background

This paper builds on the corporate governance of ownership, R&D innovation, and firm characteristics. From the perspective of corporate governance mechanisms and employee turnover, we discuss the controversies that are different from the previous literature. The article draws on debates on inverted U-shaped relationships, board size, and employee turnover. The paper extends the corporate governance literature to consider the governance effects of employee turnover, incentives, and ownership. As a result, we can formulate the research hypotheses:

H1: ESG policies focus on employee welfare measures, this paper believes that high-level employee welfare measures can help reduce employee turnover.

H2: From the perspective that the central decision-makers of corporate governance measures are board members, this paper

Tab. 1: Review of the organizational governance and the human resources

Literature (author)	Point of view	Empirical results	Expected results of the paper
(Lo & Liao, 2021)	Financial	−	+/−
(Tabassum & Batsakis, 2018)	Ownership structure	+	+
(Chiu et al., 2021)	Innovation	+/−	+/−
(Grossman, 2010)	Ownership structure	+	+/−
(Harsch & Festing, 2020)	Ownership structure	+/−	+/−
(Han & Kim, 2021)	Cash holdings	+	+
(Han & Kim, 2020)	Innovation	+	+
(Montani et al., 2020)	Innovation	+/−	+

Note: This paper was compiled with reference to the above-mentioned literature.

Source: own

believes that changes in board size will affect employee turnover.

H3: From the perspective of corporate governance, which mainly regulates the shareholding objects of major shareholders, this paper believes that changes in the shareholdings of major shareholders will affect changes in employee turnover.

H4: From the perspective of changes in business scale, this paper explores the phenomenon of different employee turnover in firms of different sizes.

H5: The firm's investment in R&D and innovation helps reduce employee turnover.

H6: From the perspective of firm financial measures, this paper believes that stable financial capabilities will inhibit employee turnover.

2. Research methodology

In Tab. 2, we introduce the types of research sample firms. In terms of sample selection, this paper mainly considers Taiwan's ESG policy, which attaches great importance to the food industry related to food safety issues. Therefore, we chose listed firms for research samples. Secondly, the original sample scope of this paper included 28 food firms, but considering the completeness of the data, we finally

Tab. 2: Sample firm introduction – Part 1

Sequence	Company name	Type of company	Founding date
1	Wei Chuan Foods Corporation	Listed firm	1953/9/22
2	Ve Wong Corporation	Listed firm	1959/7/4
3	Great Wall Enterprise Co., Ltd.	Listed firm	1960/12/28
4	Oceanic Beverages Co., Inc.	Listed firm	1965/7/24
5	Charoen Pokphand Enterprise (Taiwan) Co.	Listed firm	1977/8/22
6	Uni-President Enterprises Corp.	Listed firm	1967/8/25
7	AGV Products Corp.	Listed firm	1971/6/26
8	Taisun Enterprise Co., Ltd.	Listed firm	1960/10/21
9	Fwusow Industry Co., Ltd.	Listed firm	1955/2/7
10	Tairoun Products Co., Ltd.	Listed firm	1969/3/13
11	Formosa Oilseed Processing Co., Ltd.	Listed firm	1986/4/18
12	Standard Foods Corporation	Listed firm	1986/6/6
13	Lien Hwa Industrial Holding Corp.	Listed firm	1955/7/20
14	Lian Hwa Foods Corp.	Listed firm	1970/7/7
15	TTET Union Corp.	Listed firm	1982/5/24
16	Ten Ren Tea Co., Ltd.	Listed firm	1975/12/11
17	Hey-Song Corp.	Listed firm	1969/12/13
18	Shin Tai Industry Co., Ltd.	Listed firm	1972/11/15
19	Hunya Foods Co., Ltd.	Listed firm	1976/6/14
20	Sunjuice Holdings Co., Limited	Listed firm	2010/1/12
21	Kee Song Bio-Technology Holdings Limited	Listed firm	2010/5/11
22	Tehmag Foods Corporation	Listed firm	1989/6/29
23	Namchow Holdings Co., Ltd.	Listed firm	1950/6/30
24	Taiyen Biotech Co., Ltd.	Listed firm	1995/7/1
25	Chung Hwa Food Industrial Co., Ltd.	Listed firm	1980/5/8

Tab. 2: Sample firm introduction – Part 2

Sequence	Company name	Type of company	Founding date
26	Taiwan Fructose Co., Ltd.	Listed firm	1984/7/25
27	Forg Innovation Co., Ltd.	Listed firm	1990/10/16
28	GeneFerm Biotechnology Co., Ltd.	Listed firm	1999/07/17

Source: own (compiled with reference to the websites of various companies)

had 28 food firms as the research sample of this paper.

The model follows Fama and Jensen (1983) and Chiu and Fonda (2021) and uses the panel data model to estimate the degree of relationship between organizational governance and employee turnover during the decade 2011–2021 period as follows:

$$HR_{it} = \beta_{1i} R\&D_{it} + \beta_{2i} FP_{it} + \beta_{3i} BZ_{it} + \\ + \beta_{4i} MS_{it} + \beta_{5i} EB_{it} + \beta_{6i} BS_{it} + \varepsilon_{it} \quad (1)$$

As to employee turnover (HR_{it}), we use independent variables, including firm research ($R\&D_{it}$), free cash flow ratio (FP_{it}), board size (BZ_{it}), major shareholder holdings (MS_{it}), the employee benefits (EB_{it}), and firm asset (BS_{it}). In order to investigate organizational governance and the employee turnover, this paper elaborates on the log equation as follows. Further, we use a quantitative regression model, and further predict the end of the data distribution:

$$\min_{\beta} \left[\sum_{y_i \geq \beta x_i} \alpha |y_i - \beta x_i| + \sum_{y_i < \beta x_i} (1-\alpha) |y_i - \beta x_i| \right] \quad (2)$$

Koenker and Bassett (1978) propose the analytical method of quantitative regression, and the concept of component regression is derived from the least absolute deviation. This paper notes that if the observed value βx_i is less than the estimated value y_i, then the weight is 1 − α. Thus, we obtain a vector of a set of parameters β to obtain the minimum value for the weighted sum of the absolute values of the error terms. The α is the size of the component, and its value is between 0 and 1 ($0 < \alpha < 1$). If α is 0.5, then the component regression is the median regression.

3. Research results

Tab. 3 reports the descriptive statistics of the firm human resource mobility and R&D innovation policy. The degree of human resource mobility is between 0.000% and 92.860%, indicating a significant difference in human resource mobility.

The R&D innovation policy ranges from 0.000% to 32.270%, revealing the massive difference in the degree of R&D innovation among firms. Board sizes range from 6 to 18 people, which means that firms have different levels of board size and should place various levels of emphasis on human resources.

In the past, most discussions on the turnover rate focused on the relevance of human resources conditions. However, when the generation of ESG emphasis has arrived, it is necessary to rethink the relationship with the turnover rate from the perspective of ESG. ESG is not only about the firm's operating performance but also about using the spirit of ESG to change the firm's overall corporate culture and contribute to its sustainable development. In particular, it is observed through this paper that the turnover rate of the food industry varies greatly among firms. First of all, this paper considers that the food industry's turnover rate is 0.000% and 92.860%. It is believed that the equity structure and the degree of R&D innovation may affect the firm's turnover rate.

Secondly, why the turnover rate needs to be re-discussed because human resources have a significant impact on traditional industries, but it seems that it is not enough to explore the scope of the discussion only from the external factors. Corporate governance structure impacts the firm's operations significantly. Therefore, from the perspective of the different characteristics of the ownership structure, for example, the size of the board of directors in the food industry ranges from 6 to 18 board members, capturing the factors that affect turnover will

help the industry think about the optimal design of the ownership structure.

Finally, the degree of R&D innovation has become a critical factor in the development of firms. Still, many firms have realized that in addition to the degree of R&D innovation, how to shape long-term human resources may be a more critical factor for discussion. Because of having long-term human resources. Advantages are also reflected in the sustainable development of R&D and innovation.

3.1 Panel regression model

This paper has examined employee turnover and the degree of organizational governance effect by a panel of 28 Taiwanese food firms over the period 2011–2021. Our central estimates rely on data from TEJ sources (Taiwan Economic Journal (TEJ) database). We apply the panel regression model and present the results in Tabs. 2–3 to compare the estimates of the pooled model by OLS, taking into account board size and significant shareholders' shareholding as two organizational governance indicators.

It can be seen from Tab. 4 that the board size (−3.563) and the square term of the board size are significantly correlated with employee turnover (0.166). This means that the participation of the board size contributes to the stability of the firm's human resources. The employee turnover has a U-shaped relationship with the board of directors, which shows that a considerable board size will affect employee turnover. In addition, financial stability (−0.016), the degree of R&D innovation (−1.024), and employee welfare (−0.371) have a "–" relationship with the strength of human resources. Therefore, it shows that the firm's financial stability, the degree of R&D innovation, and employee welfare measures will affect the development of human resources.

The scale development of the board of directors has far-reaching significance in that it has affected the growth and stability of human resources. This paper found that the size of the board of directors has a U-shaped relationship with the turnover rate, indicating that the expansion of the board of directors has a significant positive relationship with human resources, which means that the development of the board of directors is not just an increase in the number of board members, but more importantly, it has a more significant impact on human resources. Therefore, this paper reminds us that the scale development and diversity of the board of directors will have a certain degree of influence on human resources with emphasis on attitude, no matter of the firm's development strategy, human resources development, soundness of the firm's operating system, etc., so the stability of human resources will be different qualitatively due to the factors of the ownership structure. In other words, the future development of the board of directors in the territory should not only focus on the business operation but also the core influencing factor to drive high-quality human resources.

The impact of the size of the board of directors on different degrees of human resources has been, according to the authors' belief, rarely discussed in the literature. Still, its importance deserves to be addressed, especially when the size of the board of directors is only

Tab. 3: Summary statistics of human resources and organizational governance

	Std. dev.	Min	Max
Employee turnover (HR_{it})	11.757	0.000	92.860
Firm research ($R\&D_{it}$)	2.701	0.000	32.270
Free cash flow ratio (FP_{it})	72.614	−715.040	571.420
Board size (BZ_{it})	2.244	6.000	18.000
Major shareholder holdings (MS_{it})	15.304	5.960	86.080
Employee benefits (EB_{it})	23.635	2.270	255.480
Firm asset (BS_{it})	1.446	11.998	20.057

Source: own (based on Taiwan Economic Journal (TEJ) database; 2019)

in a small-scale type. The board of director members may only pay attention to business performance issues but do not pay attention to the importance of human resources. Therefore, members of the board of directors will not highly professionally conceive the future development of human resources, and it is more likely that the size of the board of directors will stay in a small-scale type, losing the importance. When board members think with self-interest as the core and do not expect to expand the board's scope, the possibility of affecting human resources will be enormous.

Tab. 4: Results of parameter estimation of board size for POLS models

	Coefficient (standard errors)	*p*-value
Const	58.841***	0.000
	(14.740)	
Firm research ($R\&D_{it}$)	−1.024***	0.004
	(0.358)	
Free cash flow ratio (FP_{it})	−0.016**	0.046
	(0.007)	
Board size (BZ_{it})	−3.563**	0.028
	(1.614)	
Board size $(BZ_{it})^2$	0.166**	0.024
	(0.073)	
Employee benefits (EB_{it})	−0.371***	0.008
	(0.138)	
Firm asset (BS_{it})	−1.371***	0.009
	(0.526)	

Note: Dependent variable: employee turnover (HR_{it}); *** and **indicate significance at the 0.01 and 0.05 levels, respectively; data in brackets are standard errors.

Source: own (based on Taiwan Economic Journal (TEJ) database; 2021)

It can be seen from Tab. 5 that the major shareholders' holding (0.360) and the square term of the major shareholders' holding are significantly correlated with employee turnover (−0.006). This means that the majority shareholder's holding contributes to the firm's human resources stability. The strength of human resources has an inverted U-shaped relationship with the major shareholder holdings, which shows that expanding the major shareholder holdings will contribute to employee turnover.

Major shareholders' holding affects employee turnover, and significant shareholders' holding attaches great importance to human resources, contributing to the long-term stability of human resources. Therefore, major shareholders can implement ESG policies and attach importance to human assets, enhancing firms' sustainable development.

This paper found that the manager's shareholding ratio has an inverted U-shaped relationship with the turnover rate. On the one hand, it considers the firm's professional management; on the other hand, it pays attention to the long-term human resources development. This paper believes that the expansion of the manager's shareholding affects the turnover rate because the manager's operation management has already had a qualitative change. When the manager's shareholding ratio is too large due to the relationship of personal interests, the manager focuses

on the firm's profit more than the stability of human resources and even invests in long-term human resource development without planning. Therefore, the manager's shareholding will be an observation indicator; further thinking about how to have appropriate managers holding shares belonging to the firm's owner should be conceived of as significant issues.

Tab. 5: Results of parameter estimation of major shareholder holdings for POLS models

	Coefficient (standard errors)	*p*-value
Const	33.773***	0.007
	(12.542)	
Firm research ($R\&D_{it}$)	−1.042***	0.005
	(0.371)	
Free cash flow ratio (FP_{it})	−0.016**	0.037
	(0.007)	
Board size (BZ_{it})	0.360**	0.035
	(0.169)	
Board size $(BZ_{it})^2$	−0.006**	0.010
	(0.002)	
Employee benefits (EB_{it})	−0.437***	0.002
	(0.138)	
Firm asset (BS_{it})	−1.660***	0.002
	(0.529)	

Note: Dependent variable: employee turnover (HR_{it}); *** and ** indicate significance at the 0.01 and 0.05 levels, respectively; data in brackets are standard errors.

Source: own (based on Taiwan Economic Journal (TEJ) database; 2021)

3.2 Panel quantile regression model

The empirical results of the panel quantile regression model (Tab. 6) showed that firms with high employee turnover in the food firms had a significant "−" correlation with financial stability (−0.029), the board size (−1.130), and employee benefits (−0.683). Implicitly, these factors influence high employee turnover.

For the food firms to effectively reduce high employee turnover, factors such as financial soundness, board size, and employee benefits should be strengthened. Businesses are characterized by low employee turnover and are also very important for financial stability, board size, and employee benefits. Therefore, when a firm faces the problem of high employee turnover, it should examine its management mechanism from the above point of view.

Through the effect of firm scale, this paper finds that different scale effects impact human resources differently. Small-scale firms have a significant positive relationship with the turnover rate. However, a negative correlation exists between firm size and employee turnover, indicating that different firm sizes affect employee mobility. Large-scale firms pay attention to the attitude of human resource development and have system and planning capabilities compared with small-scale firms.

From the effect of scale, this paper found that financial soundness impacts human resource development, indicating that employees attach importance to corporate financial capabilities. Whether a small-scale or large-scale firm, the employee turnover rate is consistent with the effect of financial soundness indicators.

Secondly, this paper found that the size of the board of directors of large firms has a significant inverse relationship with the turnover rate, indicating that the board of directors of large firms is committed to human resource development, and the size of the board of directors affects

Tab. 6: Results of quantile estimates

Variables	Const	RD	FP	BZ	MS	EB	BS
OLS	54.219***	−1.555***	−0.033***	−1.129***	−0.049	−0.705**	−1.904***
	(7.232)	(0.345)	(0.008)	(0.273)	(0.0408)	(0.341)	(0.440)
0.1	4.300***	−0.060	−0.017***	−0.288***	−0.002	−0.581***	0.268***
	(3.454)	(0.108)	(0.003)	(0.130)	(0.019)	(0.160)	(0.210)
0.2	17.871***	0.103	−0.020***	−0.556***	−0.005	−0.691***	−0.237
	(5.625)	(0.176)	(0.006)	(0.212)	(0.031)	(0.265)	(0.342)
0.3	20.806***	0.298***	−0.027***	−0.702***	0.007	−0.414***	−0.295***
	(3.767)	(0.117)	(0.004)	(0.142)	(0.021)	(0.178)	(0.229)
0.4	28.678***	0.023	−0.025***	−0.767***	−0.007	−0.304***	−0.655***
	(4.570)	(0.143)	(0.005)	(0.172)	(0.025)	(0.216)	(0.278)
0.5	33.920***	−0.077	−0.026***	−0.753***	−0.023	−0.316***	−0.861***
	(4.894)	(0.153)	(0.0051)	(0.184)	(0.027)	(0.231)	(0.298)
0.6	37.317***	0.506***	−0.033***	−0.718***	0.027	−0.316**	−1.126***
	(5.401)	(0.169)	(0.006)	(0.203)	(0.030)	(0.255)	(0.329)
0.7	52.894***	0.437**	−0.028***	−0.878***	−0.015	−0.196	−1.791***
	(8.901)	(0.278)	(0.010)	(0.335)	(0.049)	(0.420)	(0.542)
0.8	67.214***	0.315	−0.024***	−1.058***	−0.046	−0.066	−2.392***
	(10.561)	(0.330)	(0.011)	(0.398)	(0.059)	(0.499)	(0.643)
0.9	86.386***	−0.045	−0.029***	−1.130***	−0.033	−0.683***	−3.044***
	(9.594)	(0.300)	(0.010)	(0.361)	(0.053)	(0.453)	(0.584)

Note: ** and *** denote 5% and 1% significance levels, respectively.

Source: own

the major development factors of human resources in the future. On the contrary, small firms must conceive how to play the effect of the board of directors on human resources and establish the degree to which board members attach importance to human resources.

Furthermore, this paper observes that under different scales, the impact of R&D innovation on the turnover rate is less consistent, which means that the effect of R&D innovation on human resources needs to consider the relevance of different levels. Finally, the employee benefits of large and small firms have a negative relationship with the turnover rate, indicating that employee benefits help reduce the turnover rate. However, in terms of management implications, business owners must consider the long-term stability of human resources; how to establish an environment conducive to the development of human resources in the long term is an urgent issue, including the development of equity structure, human resource planning, and the degree of R&D innovation. Because of these factors, it may be a measure of human resources in the future. Employees can observe these indicators as the conditions for choosing a firm suitable for long-term development. Therefore, the environment in which firms only pay attention to employee welfare conditions has passed. They should have long-term plans and goals for the environment mentioned above to meet the new operating environment that requires human resources.

The authors of this paper believe that for firms, ESG policies will put the concept of sustainable development into practice in their

management mechanisms. The shareholding structure significantly impacts the implementation of ESG policies, especially since the board of directors can influence the firm's ESG policy. Therefore, the size of the board of directors and the shareholding factors of major shareholders have been discussed in much literature in the past. Stock factors also have a positive or "–" impact on business performance.

However, the ESG policy emphasizes how the firm can develop sustainably, among which human resources have become vital to the firm's sustainable development. Through this paper, it is found that the expansion of the board of directors has an inverted U-shaped relationship with employee turnover, and the development of significant shareholder holding has an inverted U-shaped relationship with the strength of human resources. In terms of policy implications, the organizational governance of a firm affects not only the firm's business performance but also its human resources' stability.

Primarily, when a firm pursues the goal of sustainable development, it must have stable human resources to achieve the purpose of sustainable development. Therefore, when a firm develops its shareholding structure, it must also evaluate the impact on human resources. Firms attach great importance to human resources, and employees can develop innovative R&D technologies required by firms under a sound firm mechanism or assist firms in implementing environmental protection measures and other tasks. Therefore, firms can solve more problems for society and produce benefits that benefit the community.

This paper further compares and discusses relevant literature. For the corporate ownership part, this paper found that corporate ownership impacts employee turnover. Harsch and Festing (2020) explain the relationship between human resources, size, and ownership. The difference, with the same point of view, is that employee rights and interests will differ due to ownership and other factors.

In the R&D innovation part, this paper found that R&D innovation impacts employee turnover. This result is consistent with Han and Kim (2020, 2021) research results that high employee stability positively correlates with high R&D innovation.

This paper found that corporate financial policies have an impact on employee turnover, which is consistent with Wang and Yan (2022), who showed that financial policies affect human resources.

In addition, the shareholding of large shareholders impacts employee turnover, which is consistent with the research finding of Abe (2002), who found that large shareholders can reduce employee turnover.

Since corporate governance attaches great importance to the function of the board of directors, the board size, as found in this paper, impacts employee turnover. This paper emphasizes the importance of the board of directors, and this result is consistent with Villiers' (2021) emphasis on corporate governance's function in ensuring that labor needs are met.

This result is consistent with John and Senbet (1998), who agree that board effectiveness depends on the independence and size of board members. In addition, Cho (2005) showed that corporate governance provides an appropriate role in formulating policies to establish an effective human resource management system, which is also the core value expression of this paper's emphasis on corporate governance.

Finally, this paper found that employee benefits impact employee turnover. This result is consistent with the research results of Campbell et al. (2012) and Werne et al. (2005), indicating that employee benefits impact employee turnover.

Conclusions

Firms have already recognized sustainable development from the perspective of the global development of ESG policies, and corporate profit is not the only goal. More importantly, it is necessary to integrate ESG policies into the business concepts, and attaching importance to human resources is an essential foundation. From the development of organizational governance, through empirical results, it is found that the size of the board of directors has a U-shaped relationship with employee turnover, which means that appropriate board size has a significant relationship with human resources.

However, when the board of directors is too large, it may affect the employee turnover. It is worthwhile for firms to consider the size of the board of directors, and attention should be paid to the influencing factors of human resources. The proportion of shares held by principal shareholders also has a significant relationship with the development of human resources. The attitude of major shareholders' holding influences employee turnover, not just focusing on corporate profits.

Through the panel quantile regression model, this paper finds that firms are characterized by high employee turnover, their R&D innovation capabilities will be hindered, and firms' poor financial policy performance is also a concern for employees. Firms with reasonable employee welfare measures are still valued by their employees. Therefore, a stable human resource is a significant asset from the point of view of a firm. Human resources will contribute to the sustainable development of firms. Through human resources, we will practice the business philosophy of firms and solve environmental and social problems with the core value of R&D innovation.

Regarding policy implications, business owners did not pay extra attention to human resources development in the past. In the ESG era, this paper believes that business owners should have new business thinking and know how to use R&D innovation, equity structure, and other-oriented energy, which will further help. The development of human resources will be worthy of the attention of business owners. Due to the traditional nature of the food industry, high-quality human resources are necessary for breakthroughs in technology or the market. To cultivate high-quality human resources, firms should not only rely on employee welfare conditions but should also include conditions such as equity structure development, human resource planning, and the degree of R&D innovation as necessary conditions.

When the ownership structure design can help the development of human resources, it is of great significance to business owners because the representative board of directors has more professional development capabilities for human resource development. Planning drives firms to have the attitude of long-term management of human resources. Changes in these factors will affect the concept of firms' long-term business energy, attach importance to human resources for R&D innovation, and drive firms to have the ability to break through the current situation.

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The impact of environmental, social and governance policies on companies' financial and economic performance: A comprehensive approach and new empirical evidence

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Abstract: *In the last decade, the use of integrated reports (IR) comprising information on non-financial indicators from the environment, social, and governance (ESG) category has increased in time. Companies are now focusing not only on financial reporting but are notably including non-financial issues in their public reports. In doing so, they seek to align activities with the expectations of their stakeholders and the society in which they operate, as well as with various regulations, which are increasingly relevant worldwide. This study examines the impact of ESG reporting on company performance. Our research involved analyzing financial and non-financial data from 2,400 companies extracted from the Refinitiv Eikon database. Two methods of quantitative analysis were applied, namely multiple linear regression models processed by the robust regression method and structural equation modelling. Main findings entail that ESG indicators had strong and medium effects on company performance, but these effects varied across different dimensions, requiring a tailored approach to embed ESG factors in corporate strategy to enhance overall performance. Our paper provides a new perspective on the current and the potential impact of ESG reporting, based on systematic theoretical and empirical analyse , with multiple implications for business administration and management.*

Keywords: *ESG indicators, performance, corporate governance, environment, econometric modelling.*

JEL Classification: *G34, L25, M14, Q56.*

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Introduction

Environmental, social and governance (ESG) credentials have become a global trend nowadays and are increasingly important for companies due to spreading awareness of their responsibility for sustainable growth and their multi-dimensional impact on society (Kaakeh & Gokmenoglu, 2022). Sustainable development in all fields of activity is ever more demanded to become a compulsory requirement at the global level (Chien, 2023) and companies are increasingly using sustainability strategies and this has led to notable shifts in business models and management practices (Chang & Lee, 2022). Firms are implementing optimal strategies focused on maximizing stakeholder value while also achieving the company's financial goals (Al Amosh et al., 2022). The practical implementation of this new paradigm is reflected in the increasing efforts companies are making to properly assess their commitment to sustainability and global long-term development goals (Chang & Lee, 2022).

Firms are keener to publish information on their environmental, social and corporate governance principles engagement and use ESG as a means to share information on business sustainability with their stakeholders (Chang & Lee, 2022). Among the directions of this approach is a focus on indicators to measure results related to an organization's involvement in addressing environmental and social issues or implementing policies with an impact on corporate governance. These indicators are grouped in the so-called ESG (environment – social – governance) categories that integrate the results of companies' environmental, social and governance activities (Veenstra & Ellemers, 2020).

ESG indicators have become relevant for both companies and investment fund managers or shareholders (Orsato et al., 2015). Investors are increasingly considering environmental, social, and governance issues when selecting their portfolios. This information allows them to steer towards investments that can be socially and environmentally beneficial (Orsato et al., 2015). It is recommended for companies aiming to implement integrated reporting (IR) using the IIRC Framework to use company-specific determinants to encourage IR adoption (Tiron-Tudor et al., 2022). The criteria used by financial and management professionals to differentiate between various potential investments include environmental, social and corporate governance indicators.

All these are arguments for firms to consider non-monetary objectives in their activities. On the other hand, finding a balance between increasing financial performance and the complex and high expectations of different stakeholders is a challenge for business managers. They must prioritize long-term and short-term objectives and sometimes forego maximizing short-term financial performance to meet urgent corporate social and environmental objectives. This balance is often achieved when the costs of minimizing the negative environmental and social impacts of company operations do not lead to compromising corporate financial performance (Busch et al., 2011). Therefore, an increasingly relevant subject and research theme is the analysis of the links between environmental, social responsibility and corporate governance policies and organizational performance reported by companies.

Numerous studies have examined the link between ESG practices and corporate financial performance, but most of them focus on a single ESG dimension (Barnett & Salmon, 2012; Han et al., 2016; Kaakeh & Gokmenoglu, 2022; Mu et al., 2022; Wu & Li, 2023). The integrated analysis of all three dimensions is considered quite difficult to address, as ESG topics are very broad and comprehensive. In this complex framework, the current research aims to fill in the gap and address this challenge by analyzing the interplay between the ESG dimensions and companies' financial and economic performance in a new comprehensive approach. We address a general objective to assess whether ESG policy performance leads to increased economic and financial performances and to analyze the three pillars of sustainability, the so-called "triple bottom line of sustainability" (Elkington, 1997; Kouaib et al., 2020), namely that environmental performance (planet), social performance (people) and the performance of corporate governance policies lead to an increase in the economic and financial performance of companies (profit).

Our methodological endeavour is based on two advanced econometric procedures: i) multiple linear regression models processed by the robust regression method with Huber; and ii) biweight iterations and structural equation modelling (SEM). We have compiled a complex dataset covering 2,400 companies from different industries, whose results for 2016–2020 (financial and non-financial) are

included in the Refinitiv Eikon database, covering numerous ESG indicators along with indicators that reflect the financial performance of companies. This paper provides new insights that can help to identify the essential mechanisms by which ESG actions can enhance firms' financial and economic performance for each ESG dimension and pillar of sustainability. Furthermore, it outlines the strategies that companies need to design, adopt, and implement to achieve this goal. Therefore, the research study provides a new and comprehensive perspective on the relationship between ESG and firm performance. It enhances the existing literature by examining the interlinkages between specific ESG dimensions and company financial outcomes.

Through a new modelling approach based on applying two advanced econometric techniques, we bring accurate and robust results that provide a clearer picture of the role of corporate social and environmental objectives and ESG actions in shaping company activities and financial performance, with positive spillover effects on society at large. Our research stands out from previous studies due to the unique research framework we have designed. After reviewing the existing relevant literature, we have adopted a comprehensive approach that involves conducting empirical analysis using methods that are configured for separate ESG dimensions and pillars of sustainability. We use robust regression models to test the relationship between different variables and integrated SEM models to test multiple relationships simultaneously.

The paper is divided into several sections. The first section provides an introduction that explains the topic's relevance and the approach's novelty. The next section presents a critical review and bibliometric analysis of the scientific literature in the field. The paper then describes the data and indicators used in the empirical analysis, along with the methodological groundings. The final sections of the paper present the results obtained, complemented by discussion and concluding remarks.

1. Theoretical background

The number of companies using sustainability strategies and publishing information on environmental, social and corporate governance issues is growing, leading to fundamental changes in business models and management practices (Chang & Lee, 2022). The literature highlights both conventional shareholder-oriented management theories (Abdullah & Tursoy, 2023; Friedman, 1970) aimed at improving financial performance and maximizing shareholder benefits and stakeholder-oriented management theories (Freeman & McVea, 2001; Zhang et al., 2022), the latter focusing on maximizing the social value associated with environmental, social and governance (ESG) concepts. These coordinates have also been entailed by Elkington (1997), who proposed the triple-bottom line (TBL) comprising people, the planet and profit to address the issue of sustainability. Various authors further extended these concepts to the economy, the environment and society (Tseng et al., 2020). Issues related to sustainability and the ESG dimensions of a company's business are an intensely debated and controversial topic in the literature, with many studies that have analyzed the link between ESG practices and companies' financial performance.

However, most studies focus on a single ESG dimension (Barnett & Salmon, 2012; Han et al., 2016; Kaakeh & Gokmenoglu, 2022; Wu & Li, 2023), and their overall analysis is quite difficult to address, as ESG topics are very broad and comprehensive. Xie et al. (2019), in the analysis of the impact of ESG dimensions on company performance, found that the most positively impacting link with corporate efficiency is the one with governance disclosure, respectively social and environmental disclosure. The same study showed that a moderate level of ESG disclosure is positively associated with corporate efficiency. Finding a balance between increasing financial performance and the complex and high expectations of different stakeholders can be a challenge for business organizations. They have to prioritize and forego maximizing short-term financial performance to meet corporate social and environmental objectives. According to some studies, the fundamental goals of a business organization are to minimize the negative impacts of business on the environment and society through efficient corporate governance mechanisms without compromising corporate financial performance (Busch et al., 2011).

To grasp a comprehensive updated view of the research guidelines, concepts and directions that fall under this topical subject in current literature, we first performed a bibliometric analysis, followed by a systematic

review. A sample of 412 scientific articles published in relevant journals during 2021–2023 and indexed by Scopus was extracted and processed in VOSviewer, targeting the key concepts of sustainability, ESG and financial performance (Fig. 1).

Fig. 1 entails that ESG, sustainability and environmental performance, corporate social responsibility (CSR) credentials, corporate governance and firm performance are at the core of similar studies published recently on this important subject. In this way and in line with the general objective of current research, we have further structured the systematic literature review in three main directions: environment and performance, CSR and performance, respectively corporate governance and performance.

1.1 Environment and performance

The interplay between the environment (viewed from an environmental perspective) in which business organizations operate and their financial performance is also disputed in literature, with diverging results from various studies over time. According to the neoclassical theory, improved environmental performance leads to increased costs. The idea stems from the fact that by reducing pollution and improving the environment, one can achieve a marginal decrease in net benefits. Porter (1991), however, argues that compliance with environmental regulations can benefit all implicated parties. Thus, both social welfare and private benefits of companies are on an upward trend. In the same paradigm suggested by Ambec et al. (2013) it can be considered that pollution is equated

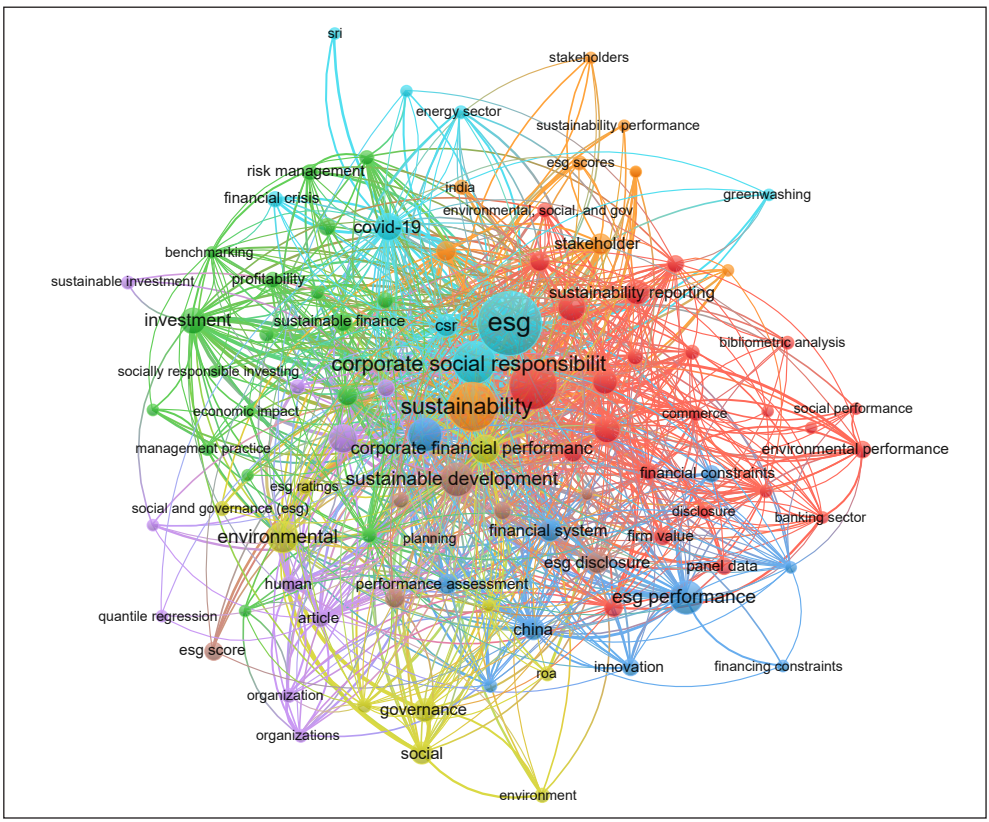

Fig. 1: **Co-occurrence and links between terms/keywords approached in relevant recent literature on sustainability/ESG and firm performance**

Source: own (in VOSviewer, using Scopus indexed scientific articles)

to a waste of resources, a reduction of which can lead to an improvement in the resources use efficiency. In other words, we can state that innovation is a catalyst for the sustainable activities of business organizations.

Lankoski (2000) and Wagner et al. (2001) have presented a third line of thought that challenges the two conventional views regarding the relationship between economic and environmental performance. They propose that the relationship between these two variables is an inverted U-shaped curve (∩), which means that there is a positive correlation between environmental and financial performance until the point where the economic benefits of environmental performance are maximized. At that point, the relationship between the two variables starts to decline.

Empirical results in scientific literature addressing the environmental (E) component follow the same divergent trend, with both views that environmental performance contributes positively to increased financial performance (Chang & Lee, 2022; Ifada et al., 2021; Konar & Cohen, 2001) and views that argue the opposite (Cordeiro & Sarkis, 1997; Lu & Taylor, 2018; Stanwick & Stanwick, 1998), as well as authors lacking a clear conclusion on this link (Cohen et al., 1997; Earnhart & Lízal, 2007a,b; Wagner, 2005). However, Wagner et al. (2001) note that the previously reviewed literature generally indicates a moderately positive relationship between two types of performance, namely environmental and financial. Kaakeh and Gokmenoglu (2022) also suggest a positive relationship, but with weak empirical evidence that environmental performance increases companies' financial performance. On the other hand, Cordeiro and Sarkis (1997) state that previous empirical proof generally reveals a negative short-term relationship between these indicators, while the long-term impact appears to be more promising.

To uncover the underlying factors influencing the variation in empirical findings regarding the relationship between environmental performance and financial performance, Horváthová (2010) conducts a meta-analysis of 64 results from 37 empirical studies. The results of this study are in line with the views of Hart and Ahuja (1996) or Konar and Cohen (2001), suggesting the importance of considering significant time intervals to show a positive effect of environmental performance on financial performance. In the same direction, Chen and Ma (2021) stated that the impact of green investment in improving firms' long-term performance can be strengthened by environmental performance. We can thus conclude that it takes a sufficiently long time for compliance with regulations from an environmental perspective and social initiatives addressing this dimension to materialize in financial performance.

Considering the above arguments, the research hypothesis (*H1*) is configured:

H1: *Environmental performance leads to an increase in the economic and financial performance of companies.*

1.2 Corporate social responsibility (CSR) and performance

Although the perception of corporate social responsibility seems to be as old as the business itself (Ferramosca & Verona, 2019), CSR was conceptually formalized by Bowen (1953), his proposed definition of the concept being the obligations of business people to pursue those policies, make those decisions, or follow those courses of action which are desirable in terms of the aims and values of our society (Bowen, 1953). Porter and Kramer (2002) argue that economic and social objectives have long been seen as distinct and often competing but this represents a false dichotomy and an increasingly obsolete perspective. Many authors argue for the need to take a strategic view of CSR, highlighting criticisms of the characteristics of the traditional approach to CSR and arguing for its consideration as a core of a firm's strategy (Maury, 2022; McBarnet et al., 2009; Perez-Batres et al., 2012; Werther & Chandler, 2011). In that way, CSR can be viewed as a part of the business strategy that can improve financial and market performance (Berber et al., 2022).

The links between corporate social performance and financial performance are still far from being clarified in literature (Ullman, 1985) and contradictory evidence expressing the relationship between them is noted, both in intensity and sign (Lahouel et al., 2021; Waddock & Graves 1997). Results from empirical work indicate an ambiguous relationship between them (Ho et al., 2021; Jacobs et al., 2016; Javed et al., 2017). One fundamental reason for the uncertainty about this relationship is the problem of measuring social performance, which is a multi-dimensional construction that

refers to a wide variety of topics. Their aggregation into a single form of measurement may suffer from inconsistency or lack of accuracy (Waddock & Graves, 1997; Wang et al., 2015).

There is evidence that CSR activities, and in particular environmental activities, can be an important source of innovation that creates additional revenue so that appropriate CSR strategies can be positively correlated with long-term corporate financial performance, being a factor in creating the competitive advantage (Ambec et al., 2013; Bocquet et al., 2017). However, despite a newly formed positive link, it remains unclear whether financially performing business organizations are more resourceful when it comes to money spent on CSR programs (Ransariya & Bhayani, 2015; Rivera et al., 2017) or whether better performance across different dimensions of corporate social performance itself leads to better financial outcomes (Edmans et al., 2017).

Those who argue for a negative relationship between social and financial performance believe that business organizations with high levels of social involvement face a competitive disadvantage (Aupperle et al., 1985) because they incur costs that could be avoided or should be supported by other stakeholders.

The two approaches outlined above are included, together with a societal approach by Van Marrewijk (2003), in an analysis leading to the identification of three perspectives on the social role of companies: i) The classical view (shareholder focus), stating that company social responsibility is represented by the action of increasing the profits (Friedman, 1970); ii) The stakeholder focus – considering that organizations should take into account the diversity of stakeholder interests (Freeman, 1984); and iii) The societal approach, with five pillars – governance, employees, community, environment, and customers, which is based on organizations taking responsibility towards the society they are part of (Liute & DeGiacommo, 2022).

Other authors (McWilliams & Siegel, 2001; Resmi et al., 2018) argue that there is a neutral relationship between social performance and financial performance of companies because firms that do not invest in CSR programs will have lower costs and benefits, while companies that do will have higher costs and customers willing to pay higher prices. There are also empirical results in the literature that support the idea that no relationship, be it positive or negative, is present in the social and financial performance of companies. Proponents of this position (Ullman, 1985) point out that there are so many intervening variables that there is no reason to argue for the idea of a relationship, except possibly by chance. Comparatively, measurement problems can shield a potential link between these indicators (Maury, 2022).

Several benefits of voluntary reporting of CSR information have been identified in relevant literature: lower corporate risk (Orlitzky & Benjamin, 2001; Orlitzky et al., 2003), lower cost of equity (Dhaliwal et al., 2011; Plumlee et al., 2015), lower cost of debt (Bauer & Hann, 2010; Goss & Roberts, 2011), higher credit ratings (Bauer & Hann, 2010), increased performance from a stock market perspective in times of financial crisis (Lins et al., 2017), optimistic analyst perceptions (Ioannou & Serafein, 2010) or improving general reputation (Barauskaite & Streimikiene, 2021).

Along these lines, it could be hypothesized that (*H2*):

H2: *Social performance leads to the increased economic and financial performance of companies.*

1.3 Corporate governance and performance

The emergence and further development of the concept of corporate governance have been associated with companies' constant attempts to improve their business in an increasingly dynamic competitive environment. The concept of corporate governance has received multiple meanings over time, being associated with management, accounting or auditing. It has often been used to describe actions taken to guide, direct and govern companies towards achieving business objectives.

The existence of a link between corporate governance and company performance has been addressed in a multitude of studies, with different findings, mainly attributable to differences in the theoretical basis of the research and the variables considered to assess corporate governance. Drobetz et al. (2004) highlighted the positive link between corporate governance and market performance, expressed by Tobin's Q ratio, results later confirmed by other studies (Strenger, 2017). Using the same performance evaluation indicator, Kiel and Nicholson (2003) found a positive relationship between the proportion of directors

elected from within the company (as an indicator of good governance practices) and the performance of companies listed on the Australian stock exchange in 1996. Dahya et al. (2008) demonstrated a positive correlation between the proportion of independent directors and Tobin's Q ratio using a sample of companies with a shareholding of at least 10% of voting rights in 22 countries, with the link being stronger for countries with low shareholder protection.

Similarly, Lefort and Urzua (2008) found a positive link between the percentage of independent directors and the same Tobin's Q ratio in a study of Chilean companies. Other studies have identified a positive link between the percentage of non-executive directors and company performance, expressed in terms of stock market returns and return on assets (O'Connel & Cramer, 2010; study of Irish companies) or between the percentage of non-executive directors and the Tobin's Q ratio (Jackling & Johl, 2009; study of Indian companies). Klapper and Love (2004) and Durnev and Kim (2005) have analyzed government ratings provided by Credit Lyonnais Securities Asia analysts for listed companies in 25 countries. The results of both studies suggest that corporate governance positively impacts company performance and value. The studies also found that this relationship is stronger in countries with less stringent investor protection standards. Benvenuto et al. (2021) conducted a study in the Romanian and Italian banking systems and identified a significant and positive, lasting influence of the IGC (corporate governance index) on financial performance expressed as profitability in both countries. Bawazir et al. (2021), through a study conducted on a sample of non-financial companies, concluded that the presence of women on the board of directors, audit committee size, financial leverage and firm size are positively correlated with company performance expressed by ROE. On the other hand, the study found a negative correlation between audit committee size, leverage, and ROA. Additionally, the study showed no mediating effect of financial leverage on the relationship between corporate governance and firm performance.

According to Ahmad-Zaluki and Wan-Hussin (2010), effective corporate governance is associated with a higher quality of financial information disclosed by companies in their periodic reports. However, the size, profitability, and industry sector-specific to each company may influence the level of reporting (Rao et al., 2012). In addition, voluntary disclosure related to corporate governance by adhering to new reporting requirements is positively associated with improved governance practices at the company level (Silveira et al., 2010).

Some studies have found no correlation or even negative links between the variables indicating corporate governance and variables that reflect the company's performance. For instance, a study by Ciftci et al. (2019) found that the increase in cross-ownership did not affect market performance when measured using Tobin's Q ratio.

In this framework, the third working hypothesis (*H3*) considered is:

H3: *The performance of corporate governance policies leads to an increase in the economic and financial performance of companies.*

2. Research methodology

The main focus of this research is to evaluate the impact of ESG reporting on company performance. To this end, the performance of ESG policies reported by companies and their correlation with indicators reflecting the economic and financial performance of companies were analyzed. To achieve this objective, two statistical approaches were employed, namely robust regression models and structural equation-based models. These methods were used to enhance the statistical significance of the results obtained in the econometric analysis. The research was conducted using a sample of 2,400 companies from various geographic areas (Europe, North America, Australia, Asia and South Africa) and sectors (classified according to Global Industries Classification Standards – GICS: Energy, Materials, Industrials, Healthcare, Financials, Information Technology, Real Estate, Communication Services, Utilities, Consumer Discretionary, Consumer Staples), with data covering the period 2016–2020, collected from the Refinitiv Eikon database. All selected companies are classified based on total assets in medium and large-sized types (minimum USD 10 million according to Internal Revenue Service – IRS; Liberto, 2023).

In order to assess the performance of the analyzed companies, five specific economic and financial performance indicators (proxies) were used: return on assets (ROA), return on equity (ROE), earnings before interest, taxes, depreciation and amortization (EBITDA), total revenues (TREVENUE) and enterprise

value (ENTVAL), and 12 independent variables reflecting ESG policies and indicators. Both dependent and independent variables were chosen by integrating previous studies which analyzed the relationship between either environmental (Kaakeh & Gokmenoglu, 2022; Wu & Li, 2023), social (Barnett & Salmon, 2012; Han et al., 2016) or governance criteria (Kara et al., 2015; Kyere & Ausloos, 2021) and financial performance. Tab. 1 captures a detailed description of all 12 variables used in the econometric modelling endeavour.

Tab. 1: Variables used in the empirical analysis – Part 1

ID/acronym	Variable	Description/definition
ROA	Return on assets (actual)	Measures a company's operating efficiency regardless of its financial structure (in particular, without regard to the degree of leverage a company uses) and is calculated by dividing a company's net income prior to financing costs by total assets
ROE	Return on equity (actual)	Represents a profitability ratio calculated by dividing a company's net income by total equity of common shares
EBITDA	Earnings before interest, taxes, depreciation, amortization	Represents company's net income before income tax expense and interest expenses are deducted for the fiscal year plus the same period's depreciation, amortization of acquisition costs, and amortization of intangibles
TREVENUE	Total revenues	Represents revenue from all of a company's operating activities after deducting any sales adjustments and their equivalents
ENTVAL	Enterprise value	Represents the sum of market capitalization, total debt, preferred stock and minority interest minus cash and short-term investments for the most recent fiscal period; market capitalization is calculated by multiplying current total shares outstanding by latest close price
RESPOL	Resource reduction policy	Captures the extent to which the company has a policy for reducing the use of natural resources or to lessen the environmental impact of its supply chain
CO2EQT	Total CO2 equivalent emissions	Represents total carbon dioxide (CO2) and CO2 equivalent emissions in tonnes; the following gases are relevant: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCS), perfluorinated compound (PFCS), sulfur hexafluoride (SF6), nitrogen trifluoride (NF3)
ENVPS	Environmental product score	Captures the extent to which the company reports on at least one product line or service that is designed to have positive effects on the environment or which is environmentally labelled and marketed; in focus are the products and services that have positive environmental effects, or marketed as which solve environment problems
DIVOPPS	Diversity and opportunity objectives score	Captures the extent to which the company sets targets or objectives to be achieved on diversity and equal opportunity; sets any objective/target to increase or promote diversity in the workplace within a time frame; includes information on the promotion of women, minorities, disabled employees, or employment from any age, ethnicity, race, nationality, and religion

Tab. 1: Variables used in the empirical analysis – Part 2

ID/acronym	Variable	Description/definition
HRIGHTSS	Human rights score	Human rights category score measures a company's effectiveness towards respecting the fundamental human rights conventions
POLBES	Business ethics score	Captures the extent to which the company describes in the code of conduct that it strives to maintain the highest level of general business ethics, along with information on respecting general business ethics or integrity and information from the code of conduct section
POLFT	Fair trade policy	Captures the extent to which the company: has a policy on fair trade; develops processes in place by which it strives to develop or market fair trade or other products based on minimum working conditions and human rights principles; gathers information to be on the final product; includes if the company develops or markets products based on SA 8000 (the global standard for decent working condition); impacted products are food (such as coffee/cocoa beans, chocolate, tea, herbs & spices, fruits & vegetables, oil, juices, wine, cereals, and sugar), footwear, clothing and cotton and precious stones such as diamond (conflict-free)
BSIZE	Board size (number of members)	Represents the total number of board members at the end of the fiscal year
BCFS	Bribery, corruption and fraud controversy score	Captures the extent to which the company is under the spotlight of the media because of a controversy linked to bribery and corruption, political contributions, improper lobbying, money laundering, parallel imports or any tax fraud
GOLDP	Golden parachute policy	Captures the extent to which the company has a golden parachute or other restrictive clauses related to changes of control (compensation plan for accelerated pay-out); considers if a large or special severance package given to top executives for their loss of office following a change in control of the company; includes accelerated vesting of share-based compensation without any conditions attached awarded to executives due to loss of office following a takeover; considers when there is a change in control clause in the employment agreement of any of the executives, in the form of severance benefits
CSRSTRS	CSR strategy score	Reflects a company's practices to communicate that it integrates the economic (financial), social and environmental dimensions into its day-to-day decision making processes
OECDMNCG	OECD guidelines for multinational companies	Captures the extent to which the company claims to follow the OECD Guidelines for Multinational Enterprises; general information on OECD is not considered such as OECD guidelines for chemical testing

Source: own (based on Refinitiv Eikon (2022) data and definitions)

Detailed statistics of all indicators employed in the empirical analysis are presented in Tab. 2.

The methodological rationale is constructed along the general assumption of this research that ESG policy performance leads to an increase in the economic and financial performance of companies. The working hypotheses are tested by applying robust regression models

Tab. 2: Descriptive statistics

	N	Mean	SD	Min	Max
ROA	8,871	0.05498	0.05995	–1.15	0.53
ROE	9,863	0.13136	0.44694	–15.53	10.35
EBITDA	11,909	1.64e+09	4.18e+09	–1.45e+10	8.18e+10
TREVENUE	11,965	1.01e+10	2.25e+10	–9.09e+09	4.25e+11
ENTVAL	11,500	18.38522	43.53669	–129.40	1209.87
RESPOL	8,061	0.85262	0.35450	0.00	1.00
CO2EQT	5,391	5,560,030	1.99e+07	253.70	3.78e+08
ENVPS	7,969	39.81570	37.27616	0.00	98.85
DIVOPPS	7,864	23.97778	40.50116	0.00	98.53
HRIGHTSS	8,061	35.98810	34.22938	0.00	99.14
POLBES	8,061	46.74917	24.52577	0.00	89.26
POLFT	8,062	0.02047	0.14160	0.00	1.00
BSIZE	7,967	11.00251	3.32226	1.00	31.00
BCFS	7,974	53.97166	19.16557	0.00	63.17
GOLDP	4,746	0.67003	0.47025	0.00	1.00
CSRSTRS	7,974	45.85497	32.97978	0.00	99.88
OECDMNCG	7,975	0.07699	0.26659	0.00	1.00
***N* total**	11,996				

Source: own

(RREG) with Huber and biweight iterations and structural equation modelling (SEM).

The robust regression models (RREG) are designed for each research hypothesis as in Equations (1–3).

H1: Environmental performance leads to an increase in the economic and financial performance of companies.

$$ROA_{it}/ROE_{it}/EBITDA_{it}/TREVENUE_{it}/EntVAL_{it} = \\ = \beta_0 + \beta_1 RESRPOL_{it} + \beta_2 CO2EQT_{it} + \\ + \beta_3 ENVPS_{it} + \varepsilon_{it} \quad (1)$$

where: *ROA* – return on assets (actual); *ROE* – return on equity (actual); *EBITDA* – earnings before interest, taxes, depreciation, amortization; *TREVENUE* – total revenues; *EntVAL* – enterprise value; *RESRPOL* – resource reduction policy; *CO2EQT* – total CO2 equivalent emissions; *ENVPS* – environmental product score.

H2: Social performance leads to the increased economic and financial performance of companies.

$$ROA_{it}/ROE_{it}/EBITDA_{it}/TREVENUE_{it}/EntVAL_{it} = \\ = \beta_0 + \beta_1 DIVOPPS_{it} + \beta_2 HRIGHTSS_{it} + \\ + \beta_3 POLBES_{it} + \beta_4 POLFT_{it} + \varepsilon_{it} \quad (2)$$

where: *DIVOPPS* – diversity and opportunity objectives score; *HRIGHTSS* – human rights score; *POLBES* – business ethics score; *POLFT* – fair trade policy.

H3: The performance of corporate governance policies leads to an increase in the economic and financial performance of companies.

$$ROA_{it}/ROE_{it}/EBITDA_{it}/TREVENUE_{it}/EntVAL_{it} = \\ = \beta_0 + \beta_1 BSIZE_{it} + \beta_2 BCFS_{it} + \beta_3 GOLDP_{it} + \\ + \beta_4 CSRSTR_{it} + \beta_5 OECDMNCG_{it} + \varepsilon_{it} \quad (3)$$

where: *BSIZE* – board size (number of members); *BCFS* – bribery, corruption and fraud

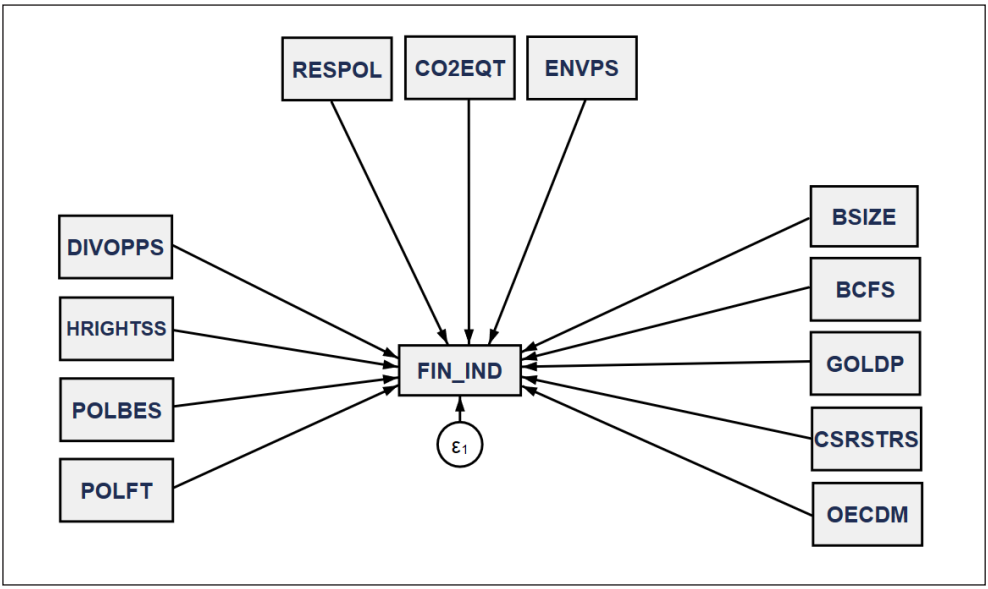

Fig. 2: **General configuration of the structural equation model**

Source: own

controversy score; *GOLDP* – golden parachute policy; *CSRSTR* – CSR strategy score; *OECDMNCG* – OECD guidelines for multinational companies.

The general configuration of the structural equation model is presented in Fig. 2.

Both advanced econometric modelling procedures provide robust estimates and allow to capture direct, indirect and total linkages between considered variables in a comprehensive approach. Hence, robust regression models firstly calculate Cook's distance and start the iteration process based on two types of iterations, Huber and biweight, to drop the outliers in the sample, thus avoiding spurious regression. Further, structural equation models allow to test multiple relations simultaneously, the coefficients associated with the SEM models being estimated through the maximum likelihood (MLE) procedure with missing values.

3. Results and discussion

Tabs. 3–5 show the results of our robust regression models and present a series of reliable estimates that we obtained from the empirical analysis. We used Equations (1–3) to apply the robust regression (RREG) and assess the effect of environmental (Tab. 1), social (Tab. 2) and governance (Tab. 3) ESG factors on companies' financial performance.

The main results show that there is a significant positive correlation between resource reduction policies (RESPOL) and return on equity (ROE), as well as earnings before interest, taxes, depreciation, and amortization (EBITDA). This can be explained by the fact that resource reduction policies can lead to a decrease in company costs. There is also a positive correlation between resource reduction policies (RESPOL) and total revenues (TREVENUE), entailing that resource reduction policies can increase the volume of sales revenue due to lower costs, allowing companies to deliver products at lower prices while still making a profit (volume increase compensates for price decrease).

On the other hand, there is a negative correlation between the increase in total CO2 emissions and ROA (economic performance), ROE (financial performance) and ENTVAL. The increase in the CO2 equivalent emissions total indicator (CO2EQT) causes a negative

Tab. 3: Robust regression results on the environmental indicators linked with economic and financial performance (*H1*)

	ROA	ROE	EBITDA	TREVENUE	ENTVAL
RESPOL	0.64100	1.80600*	0.55100**	0.48600**	0.21600
	(0.34800)	(0.67900)	(0.09570)	(0.08650)	(0.55100)
CO2EQT	−2.46e−08**	−3.01e−08**	2.15e−08**	1.93e−08**	−1.45e−08*
	(2.96e−09)	(6.14e−09)	(8.12e−10)	(7.44e−10)	(4.66e−09)
ENVPS	−0.00581**	−0.00418	0.00479**	0.00691**	0.00332
	(0.00164)	(0.00333)	(0.00046)	(0.00042)	(0.00267)
_cons	4.61800**	10.22000**	19.99000**	21.79000**	11.64000**
	(0.34300)	(0.66600)	(0.09410)	(0.08490)	(0.54200)
N	4,821	5,062	5,245	5,313	5,139
***R*²**	0.01700	0.00600	0.14400	0.16400	0.00200

Note: Standard errors in parentheses; *$p < 0.01$; **$p < 0.001$.

Source: own

influence (small, however) on economic and financial performance (ROA, ROE). On the one hand, this influence may be driven by carbon footprint penalties. In the case of the correlation with ENTVAL, one explanation is that for the markets as a whole, investors react to environmental issues, even if the intensity of the reaction is low. In the case of the correlation of this indicator with TREVENUE, one explanation lies in the fact that revenues may be associated with a higher volume of activity (production), which would lead to a higher volume of CO2 emissions. The correlation between total CO2 equivalent emissions and EBITDA is positive. One explanation could be that EBITDA does not reflect global tax benefits/penalties related to polluting activities, which would lead to this direct positive link between the two indicators. The same results were obtained by Chen and Ma (2021), who have outlined that the firm's financial outcomes have notably improved after constant investment in energy conservation and emission reduction for several years.

In the case of the link between ENVPS and ROA there is a negative relationship (negative estimated coefficient, statistically significant at the 0.1% threshold). These results are opposite to those of Ifada et al. (2021), who showed that investing in environmentally quality products proves a strong commitment by companies to achieve environmental performance that further induces a significant positive effect on firms' financial performance. A possible explanation of our estimations is that products and production lines included in ENVPS may require additional investments (increase in total assets), leading to a reduction in ROA, at least in the short and medium term. Companies reporting this product or process certification related to the environment generally have higher investments or operational expenses related to these certifications, which, on the one hand, justifies their public visibility (with the desire/intent to gain a green notoriety on the market), and on the other hand, leads to lower ROA. Regarding the link between this indicator and EBITDA, i.e., TREVENUE, there is a significant positive correlation, explained by the potential increase in sales (and thus revenues) due to the marketing of certified products with various green labels. Along the same lines, Chen and Ma (2021) also substantiated that environmental performance and green investment would significantly improve firms' long term performance.

In the case of the DIVOPPS indicator (Tab. 4), there is a negative influence on ROA, ROE and ENTVAL. One explanation is related to equal opportunity policies that do not directly translate into effects such as improved economic and financial performance, reflecting a rather neutral perception of various stakeholders (especially investors, customers or suppliers), being perceived positively only by stakeholders

Tab. 4: Robust regression results on social indicators linked with economic and financial performance (*H2*)

	ROA	ROE	EBITDA	TREVENUE	ENTVAL
DIVOPPS	−0.00582**	−0.02230**	0.00352**	0.00489**	−0.01990**
	(0.00130)	(0.00264)	(0.00036)	(0.00032)	(0.00221)
HRIGHTSS	−0.00183	0.01740**	0.00927**	0.00804**	0.00297
	(0.00164)	(0.00329)	(0.00044)	(0.00039)	(0.00273)
POLBES	0.00926**	0.03050**	−0.00049	−0.00294**	−0.00195
	(0.00216)	(0.00438)	(0.00057)	(0.00051)	(0.00355)
POLFT	1.30800**	3.57500**	−0.00744	0.46200**	2.99100**
	(0.34900)	(0.70900)	(0.09520)	(0.08540)	(0.58200)
_cons	4.80600**	10.62000**	20.23000**	22.19000**	13.02000**
	(0.11400)	(0.23200)	(0.03020)	(0.02700)	(0.18700)
N	6,819	681	7,731	7,861	7,581
R^2	0.00800	0.01900	0.09600	0.11900	0.01400

Note: Standard errors in parentheses;*$p < 0.01$; **$p < 0.001$.

Source: own

in the civic spectrum. In addition, operational costs may increase even through the provision/implementation of equal opportunities policies (e.g., increased integration costs for employees and board members from different cultural backgrounds). Revenues may increase in this situation, but it does not compensate for increased costs. In the case of the link between this indicator and EBITDA, i.e., total revenues (TREVENUE), there is a positive correlation. One explanation is linked to the open organizational culture that is created by the diversity of a company's employees and which also creates diversity in terms of sold products/services, which can also lead to an increase in revenues. The same results were also obtained by Bawazir et al. (2021) which found that board diversity is positively correlated with company performance expressed by ROE.

There is a positive correlation between the HRIGHTSS indicator and ROE. One explanation is related to the avoidance of additional costs related to sanctions for labour and human rights violations, which reduces ROE. There is also a positive correlation of this indicator, both in terms of the link with EBITDA and total revenues. These results show the positive reactions of stakeholders (less investors, as no significant links of this indicator with enterprise value were found) to positive actions of companies in the field of fundamental human rights, especially if these actions are also promoted/highlighted in their IR.

There is a positive correlation between the policy business ethics score (POLBES) and ROA, i.e., ROE. Improved economic and financial performance can be a positive outcome of adhering to ethical codes and policies. This is because a standardized and assumed ethical climate at the organizational level can lead to better productivity, especially among employees. Despite the potential benefits, stakeholders' perception of the link between ethics and performance is generally low in intensity. According to a study conducted by Lins et al. in 2017, perceptions of stakeholders and investors play an important role in establishing a trustworthy relationship with a firm. The study analyzed a sample of 1,673 non-financial firms in the US and found that investing in social capital can help build this relationship and have a positive impact on a firm's performance. In this way, Zhang et al. (2022) suggest that the managerial stakeholder approach tends to be more robust in guiding companies towards sustainable development than the ethical stakeholder perspective.

In the case of the total revenues (TREVENUE) indicator, the negative correlation can be explained by the possible perception of green-washing policies at a customer level,

Tab. 5: Robust regression results on corporate governance indicators linked with economic and financial performance (*H3*)

	ROA	ROE	EBITDA	TREVENUE	ENTVAL
BSIZE	−0.27500***	−0.33400***	0.11800***	0.11100***	−0.13400***
	(0.02450)	(0.05560)	(0.00555)	(0.00472)	(0.03740)
BCFS	0.00156	−0.01710*	−0.01510***	−0.01350***	0.00473
	(0.00339)	(0.00798)	(0.00079)	(0.00068)	(0.00531)
GOLDP	0.00705	0.70800*	0.18600***	−0.03890	1.56200***
	(0.15200)	(0.34900)	(0.03470)	(0.02970)	(0.23200)
CSRSTRS	−0.01560***	−0.02660***	0.01290***	0.00986***	−0.01930***
	(0.00224)	(0.00512)	(0.00050)	(0.00043)	(0.00338)
OECDMNCG	0.67500**	0.12400	0.35500***	0.37600***	0.21300
	(0.25300)	(0.59000)	(0.05980)	(0.05110)	(0.39700)
_cons	8.80900***	19.43000***	19.46000***	21.4900***	13.8800***
	(0.36800)	(0.85000)	(0.08390)	(0.07140)	(0.56000)
N	4,067	4,381	4,658	4,737	4,558
R^2	0.05500	0.02200	0.36100	0.37800	0.03100

Note: Standard errors in parentheses; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Source: own

which leads to a reluctance to purchase goods/services.

A positive correlation can be observed between the POLFT indicator and ROE, ROA, TREVENUE and ENTVAL. One possible explanation is that these policies have led to an increase in revenue that surpasses the cost increases. This may be due to the growing public interest in fair-trade processes and products. The study also found that investors are more likely to respond positively to companies that include fair-trade information in their reporting.

The correlation between board size (BSIZE) and ROA, respectively ROE, is negative (Tab. 5). One explanation is the increase in annual operating expenses due to higher salaries and bonuses received by more board members. As regards the relationship between board size (BSIZE) and EBITDA, respectively total revenues (TREVENUE), there is a positive correlation. Larger and more diverse boards may be associated with larger companies having higher business volumes (total revenue; Pirtea et al., 2015). A statistically significant negative correlation is found between board size (BSIZE) and enterprise value (ENTVAL), indicating that investors generally react negatively to a large number of board members.

In the case of the link between BCFS and ROE, EBITDA and TREVENUE, a negative correlation is found. A plausible explanation is related to the public perception, which shifts in a negative direction when a company is associated with such controversies, leading to decreases in revenues and, thus profitability. The relationship between Golden Parachute (GOLDP) and ROE, EBITDA and ENTVAL is positive. Potential safety nets granted to managers may represent guarantees in the view of investors for quality management processes with implications for company performance and market value.

The impact of the CSR strategy score (CSRSTRS) on ROA, respectively ROE, is negative according to our estimations and might suggest that the implementation of CSR programmes can lead to assumed cost increases and, therefore, to reductions in returns. The correlation is positive in the link with EBITDA and total revenues (TREVENUE). One explanation in this regard lies in the fact that EBITDA does not reflect the tax benefits that exist globally with reference to the implementation of CSR programmes. For TREVENUE, the positive impact is associated with favorable stakeholder (especially customer) perceptions, especially if

these actions are also publicly reported. There is a negative impact of CSR strategy score (CSRSTRS) on enterprise value (ENTVAL) (model 5 in Tab. 5, negative estimated coefficient, statistically significant at the 0.1% level). This result is in line with the Friedmanian position that the involvement of companies in social responsibility actions directly affects the share of value-added that would accrue to investors, who act accordingly (Friedman, 1970). In a different approach, other authors (McWilliams & Siegel, 2001; Resmi et al., 2018) argue that there is a neutral relationship between CSR outcomes and the financial performance of companies. OECDMNCG exerts a favorable and notable influence on ROA (model 1 in Tab. 5, positive estimated coefficient, statistically significant at the 0.1% threshold), as compliance with good governance principles can positively influence economic and financial performance and firm profitability. In the case of EBITDA and TREVENUE there is a positive correlation. The efficiency of the whole value chain driven by the application of good governance principles generates effects including on revenues (better management of distribution networks) and costs (better management of supply structure).

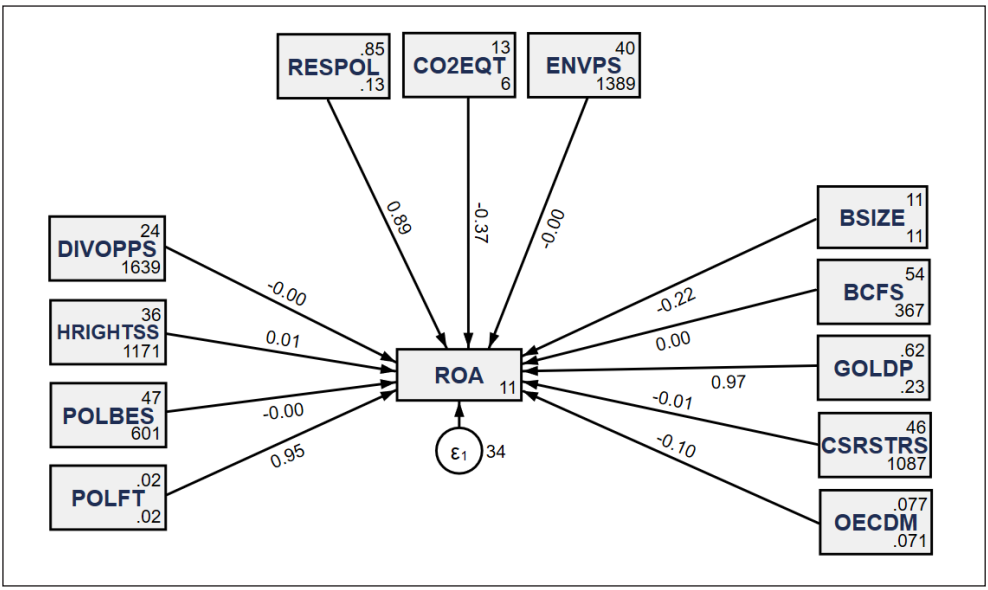

Fig. 3: **Main results of the SEM 1 model (ROA as proxy for company financial performance)**

Source: own

SEM 1 results presented in Fig. 3 entail relatively small effects on ROA induced by HRIGHTSS, CSRSTRS, OECDM, while CO2EQT, BSIZE exert medium effects and POLFT, RESPOL, GOLDP exert large impacts on company financial performance measured by ROA. The notable effects on economic performance (as measured by ROA) induced by the three indicators (one indicator in each category) can be explained by the significant increase in revenues due to fair trade implementation policies, decrease in resource consumption and efficiency of managerial processes due to the existence of golden parachutes. On these lines, Ahmad-Zaluki and Wan-Hussin (2010) have also substantiated that effective corporate governance is associated with higher profitability and improved quality of financial information disclosed by firms.

The second SEM model (Fig. 4) encompasses that the variables DIVOPPS, HRIGHTSS, POLBES, BSIZE, BCFS, CSRSTRS exert small

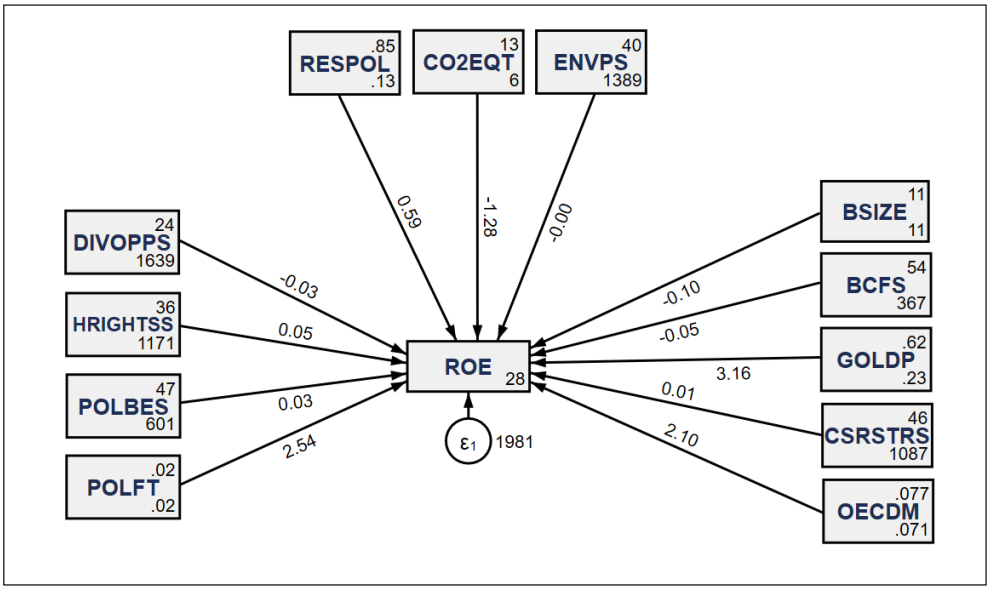

Fig. 4: **Main results of the SEM 2 model (ROE as proxy for company financial performance)**

Source: own

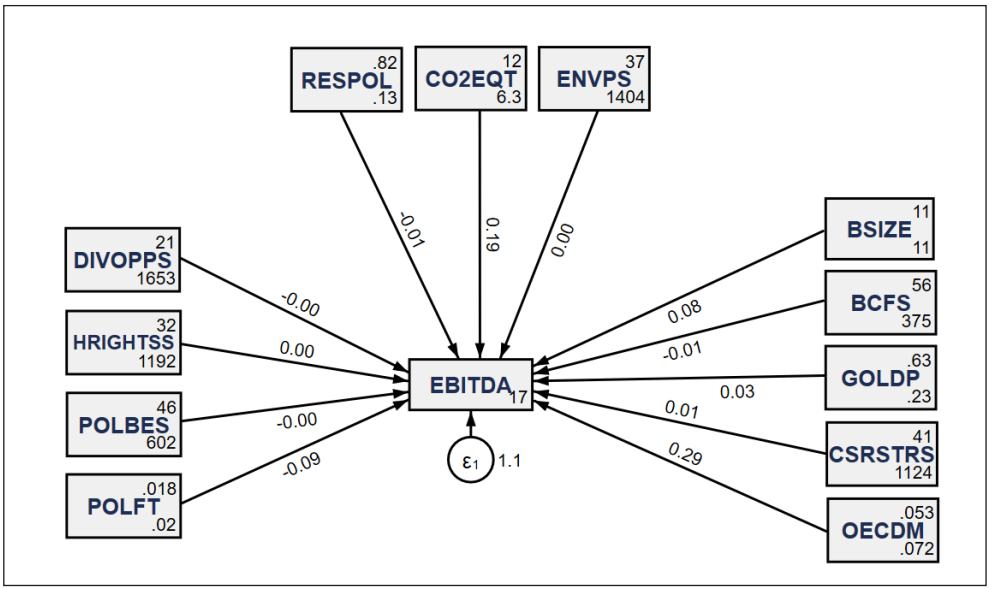

Fig. 5: **Main results of the SEM 3 model (EBITDA as proxy for company financial performance)**

Source: own

effects on ROE, while the variables POLFT, RESPOL, CO2EQT, GOLDP, and OECDM exert large effects on ROE. These results are in line with Bawazir et al. (2021), who also concluded a positive correlation between board characteristics, financial leverage, and company performance expressed by ROE. The large effects on financial performance (as measured by ROE) found for five indicators have similar explanations, providing additional arguments for lower operational costs as a result of reduced carbon emissions and for increased efficiency of managerial processes due to the application of OECD corporate governance principles.

The third SEM model (Fig. 5) entails that the variables POLFT, RESPOL, BSIZE, BCFS, GOLDP, and CSRSTRS exert small effects on EBITDA, while CO2EQT and CSRSTRS have medium effects on EBITDA. None of the indicators analyzed have large effects on EBITDA, as performance measured by gross operating profit is not directly influenced by social, environmental and governance performance.

In Fig. 6 the following variables exert small effects on TREVENUE: RESPOL, BSIZE, BCFS, while POLFT, CO2EQT, GOLDP, and OECDM exert medium effects on TREVENUE. The non-existence of indicators with large effects on total revenue is explained by the fact that performance measured solely by revenue has a stronger multi-dimensional determination (i.e., market conjuncture).

Lastly, the final SEM model (Fig. 7) entails that variables DIVOPPS, HRIGHTSS, ENVPS, BSIZE, BCFS, CSRSTRS exert small effects on ENTVAL, while only OECDM induces medium effects on ENTVAL. The following variables exert large effects on ENTVAL: POLFT, RESPOL, CO2EQT, GOLDP. These indicators influence firm value from the perspective of investors, who are interested in the impact generated by the implementation of environmental, social and governance policies (Pirtea et al., 2015). In this sense, investors sanction entities for non-compliance with social (POLFT) and environmental (RESPOL, CO2EQT) policies respectively and reward those entities that apply corporate governance policies through Golden Parachute policies for managers.

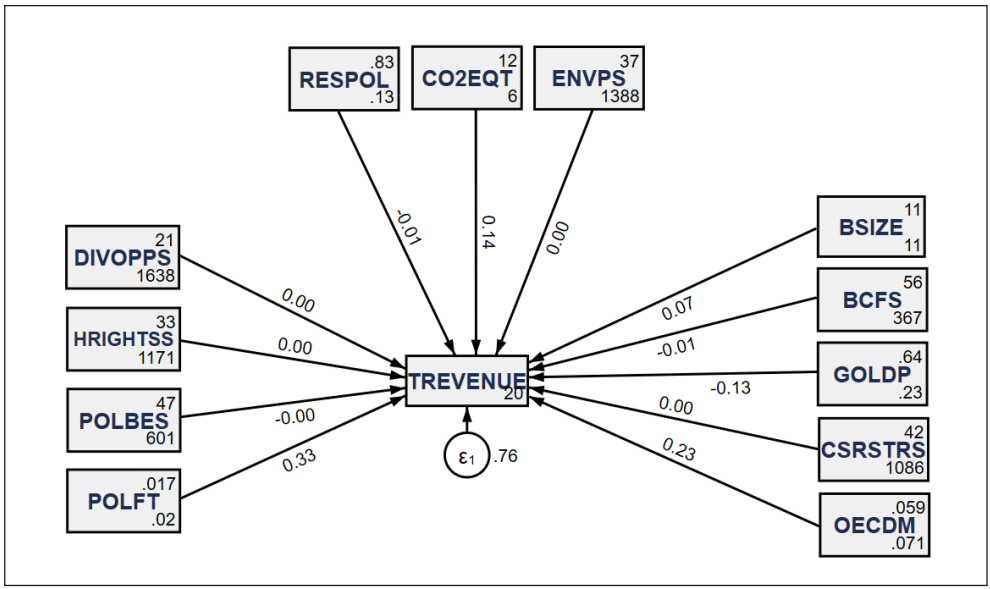

Fig. 6: **Main results of the SEM 4 model (TREVENUE as proxy for company financial performance)**

Source: own

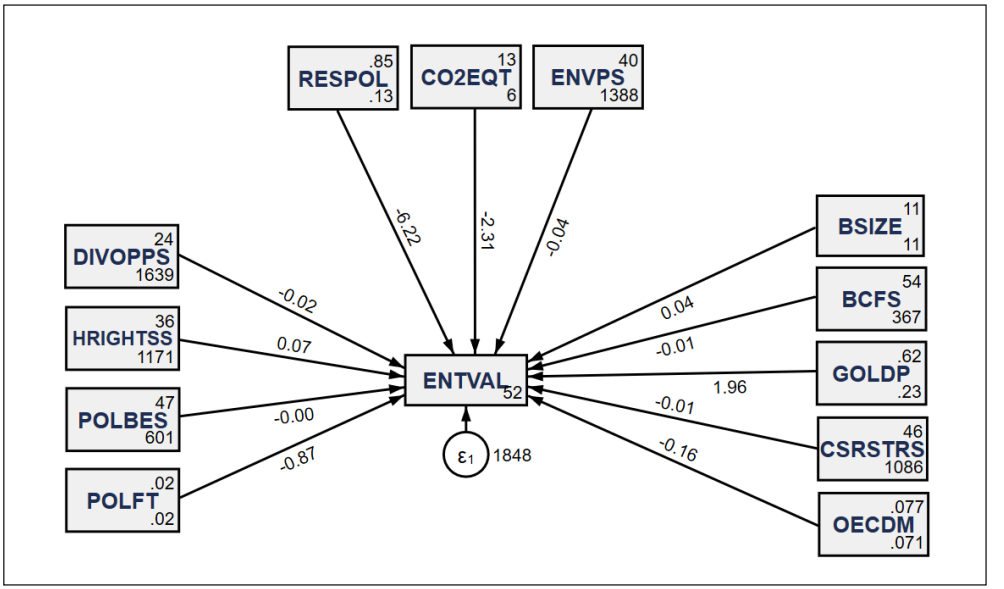

Fig. 7: **Main results of the SEM 5 model (ENTVAL as proxy for company financial performance)**

Source: own

3.1 Hypotheses validation

The results of the robust regression models have entailed that hypothesis *H1* is partially validated by the positive correlation between resource reduction policy (RESPOL) and ROE, EBITDA, respectively total revenues (TREVENUE), as well as between total CO2 equivalent emissions (CO2EQT) and EBITDA, respectively TREVENUE and between ENVPS and EBITDA, respectively TREVENUE.

In the case of hypothesis *H2*, robust regression estimations proved that it is partially validated by the positive correlation between DIVOPPS and EBITDA, respectively TREVENUE, between HRIGHTSS and ROE, EBITDA, respectively TREVENUE, between POLBES and ROE, respectively ROA and between POLFT and ROE, ROA, TREVENUE and ENTVAL.

The third working hypothesis *H3*: "The performance of corporate governance policies leads to an increase in the economic and financial performance of companies" is partially validated by the positive correlation between BSIZE and EBITDA, respectively TREVENUE, as well as between GOLDP and ROE, EBITDA and ENTVAL, between CSRSTRS and EBITDA, respectively TREVENUE and between OECDMCG and ROE, EBITDA, respectively TREVENUE.

Moreover, the results of structural equation models entail strong interdependencies between several key indicators from each considered dimension and the financial performance of companies considered in the analysis.

Therefore, the general hypothesis "ESG policy performance leads to an increase in companies' economic and financial performance" is partially validated.

Our results are in line with the findings of other researchers. For example, Friede et al. (2015) have shown that knowledge on the financial effects of ESG criteria remains fragmented (the issue that assumptions about the financial effects of ESG indicators are only partially valid). They combined the findings of about 2,200 other previous individual studies and concluded that the business case for ESG is empirically very well founded. Moreover, the authors underlined that approximately 90% of the analyzed studies found a nonnegative relationship between ESG and corporate financial performance and that a significant number of these studies report positive findings

with a stable ESG impact over time. Other researchers, like El Khoury et al. (2021), identified U-shaped correlations between ESG indicators and financial performance in research conducted for the banking industry, one of their main recommendations being that the analyses performed by business organizations should determine a turning point that leads to a decrease in the marginal benefits of ESG policies.

Conclusions

This research aimed to identify the influence of ESG credentials on financial performance in a comprehensive framework considering the three pillars of sustainability. Through a new modelling approach, two advanced econometric methods were applied to a newly compiled dataset of companies from various fields to test three research hypotheses, each corresponding to a dimension of the ESG triad. The results obtained from the robust regression models demonstrated that all hypotheses were partially validated, our study confirming fragmentary links between ESG indicators and financial performance.

The main theoretical implications of our findings are given by the integration within a conceptual model of various ESG indicators with multiple economic and financial indicators with robust evidence that can strengthen the knowledge and fill multiple gaps in this field. As regards the practical implications, the findings are relevant for managers as strategic guidelines for considering the impact of transparency: i) of information on the implementation of corporate policies aimed at reducing resource consumption; or ii) of information concerning the true value of sissiosans respectively, on the environmental characteristics of products/services that positively influence both the result of the activity (EBITDA) and its volume.

Our estimations reveal that the effect is transmitted differentially by the three considered indicators (RESPOL, CO2EQT, ENVPS). On one hand, these influences are due to lower costs resulting from lower resource consumption. On the other hand, they are determined by the increase in the volume of activity and sales, both due to the environmental consumption characteristics of products/services and the direct link between CO2 emissions and volume of activity. The most significant result is given by public information about corporate policies regarding resource consumption reductions, and the least significant effect is generated by the information about CO2 emissions.

Managers should also consider the transparency of information on social indicators that induce a cumulative positive influence on the volume of activity and implicitly on the volume of sales (TREVENUE). This further shows a positive reaction of stakeholders (primarily customers) to companies' active policies regarding diversity, defending human rights, the implementation of business ethics, and fair trade principles. As for the other categories of economic and financial indicators, the effects of information on social credentials are varied, revealing specific reactions of different stakeholders (investors could react differently and less positively than customers to ethical and social policies of companies), which are also worth considering in future managerial strategies. Another practical implication could emerge from the evidence brought to attest that the transparency of information regarding corporate governance indicators has predominantly positive effects on the EBITDA result and activity volume indicators (like TREVENUE), demonstrating a positive reaction from various categories of stakeholders (mainly customers and suppliers).

In summary, the ESG effects on profitability indicators (ROA and ROE) as well as on the enterprise value (ENVAL) are diverse. At one end of the spectrum, investors may react negatively to information about a high number of board members or controversies about bribery, corruption or fraud, with a negative effect on company value. On the other hand, allocating resources to CSR policies can lead to reduced profitability, at least in the short term. All the above-stated issues need to be addressed further and embedded in strategic and policy endeavours.

Our research is not without limitations entailed by a relatively reduced availability of data for certain indicators. One possible constraint of this study may reside on the indicators chosen to quantify the ESG domains (three indicators for the environmental domain, four indicators for the social domain, and five indicators for the corporate governance domain), as there is a wide range of indicators throughout literature respectively a multitude of other indicators. However, this limitation constitutes the groundings for future research endeavours that may consider other corporate aspects of the ESG spectrum to fully understand their

impact on company performance. Another limitation occurs because the sample comprised companies from both financial and non-financial sectors, which have many different structural aspects of corporate governance and reporting practices. Thus, future research perspectives may focus on studies of more structurally compatible sectors, such as exclusively financial or non-financial sectors, along with analyses of the sustainability challenges faced by companies in a digital globalized economy during pandemic and post pandemic times.

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Effectiveness factors of small and medium-sized enterprises from the perspective of corporate culture: A case study in Slovakia

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Abstract: *To reach business success, a company can use and manage a lot of seemingly inconspicuous and useful tools. One of them is corporate culture. The purpose of the paper is to define the factors that affect business efficiency from the perspective of corporate culture. The Organizational Culture Assessment Instrument (OCAI) was used. For data analysis, the Beta regression method, inductive statistics, and Tukey's test were used. Based on the research results, it can be stated that there are significant differences in factors that affect the business efficiency of small and medium-sized enterprises in Slovakia from the perspective of corporate culture. The results show that effectiveness factors typical for clan corporate culture, such as teamwork, communication, loyalty, and human resource development, are applied in small enterprises. However, medium-sized enterprises are dominated by a hierarchical corporate culture with an emphasis on regulations, procedures, stability, control, and accuracy of management. It can be concluded that clan corporate culture is the best type of corporate culture for small and medium-sized enterprises in Slovakia. It is recommended to see the success of the enterprise in relation to caring for the people because employees represent a strategic tool in management that can influence the effectiveness of all business processes.*

Keywords*: Business process effectiveness, corporate culture, OCAI, SMEs.*

JEL Classification: *M14, A13.*

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Introduction

The main economic objective of any business entity is to achieve a profit. Long gone are the days when the only competitive advantage was merely a product or a service and their price. At present, enterprises are realising that not only the interpersonal side of relationships and behavior of employees, but also their manners of communicating with customers play an essential role, all being much more valued

than the price itself. In that respect, a tool that may add to a certain willingness of employees to commit themselves to enterprise goals involves corporate culture. Generally, it is seen as a relatively closed and specific cultural system formed by values that organisations profess, as well as standards or rules that are followed in achieving previously set targets. A large number of enterprises have come to realise that corporate culture is a competitive advantage, which means they draw a great deal of attention to it, present it externally and define factors that represent what is important for employees.

Corporate culture is an interesting research topic for researchers and practitioners. It was analysed in terms of the analytical approach (Harrison, 1972), as well as in terms of the levels of business risk and market feedback (Deal & Kennedy, 1982). Widely used is the typology of Cameron and Quinn's (1999). It is based on the Organizational Culture Assessment Instrument (OCAI), which defines a set of different factors that affect business efficiency. The characteristic features of the environment and atmosphere, human relations, internal processes, leadership abilities, managerial style, rational goals, and open systems prevailing in the enterprise are examined. These factors are examined in six dimensions, i.e., dominant characteristics, organisational leadership, management of employees, organization glue, strategic emphases, and criteria of success. The aim of the research is to define the effectiveness factors of small and medium-sized enterprises (SMEs) from the perspective of corporate culture.

The structure of the paper is as follows: firstly, the literature review is presented. It is followed by the aim of research and methodology of research. Finally, the research findings and conclusions are presented.

1. Theoretical background

The changes in the economy, as well as globalisation and sustainability, influence the whole society (Barbu & Tudor, 2021; Chebli et al., 2020). Only enterprises that strive to build functioning strategic processes (Dvorský et al., 2020; Makovicka Osvaldova et al., 2021) support the overall performance (Lee & Ha-Brookshire, 2018) and sustainability of the company (Neykov et al., 2021) may survive. From a general perspective, corporate culture is a very effective tool. It distinguishes one organisation from another, as confirmed by the research of Bavik (2016). It may support employee effort, increase personal initiative and quality of work, promote loyalty and accountability to the respective organisation and streamline internal communication (Teräväinen et al., 2018). Furthermore, corporate culture is a system of opinions, values, and behaviours that are unique to individual enterprises (Edelstein et al., 2012; Erčulj, 2009). Each corporate culture should be pre-set and strategically managed so that it is adhered to, allows a particular enterprise to be identified accordingly in the market and is easily recognisable to potential customers, suppliers, or even job seekers (Galera & Calpena, 2014; Matraeva et al., 2018). Also, applied corporate culture is a determinant of a company's success, as it is possible to influence employee behaviour and performance through a system of values, norms, and habits (Graham et al., 2013; Samad et al., 2018).

In a number of countries, the OCAI questionnaire, introduced by Cameron and Quinn (2006), is frequently used in research on corporate culture of various institutions in order to define the effectiveness factors from the perspective of corporate culture (Brooks, 2007; Fralinger & Olson, 2007). The OCAI follows from the competing values framework, where the most decisive factors that affect the effectiveness of an organisation were identified (Cameron & Quinn, 2006). The list was subjected to a statistical analysis whose results pointed to two elementary dimensions consisting of a set of four factors. The first gauge differentiates effectiveness criteria that accent flexibility, the independence of decision-making and dynamism, as well as criteria focused on stability, order, and control. The next dimension discerns effectiveness criteria emphasising internal orientation, integration and compliance with criteria that accentuate external orientation, variety, and competition. The combination of both dimensions resulted in establishing four types of corporate culture, each of which encompasses a diverse set of effectiveness factors representing employee values relevant to organisational performance. Moreover, the factors define what is perceived as suitable and/or satisfactory and simultaneously characterise the underlying values according to which an organisation evaluates itself. The OCAI allows one to identify the dominant direction of an organisation. The OCAI determine the type, strength, and congruence of the prevailing culture (Cameron

& Quinn, 2006). In total, it is possible to detect different types of corporate culture, i.e., hierarchy, market, clan, and adhocracy.

Based on the research of Cameron and Quinn (2006), "hierarchy" corporate culture has its origins in the early corporate approaches of the modern era at the beginning of the 20th century, when producing goods and services for increasingly complex society was the greatest challenge for companies. In order to meet the challenge, seven principles of bureaucratic management were established, namely rules, specialisation, merit, hierarchy, separate ownership, impersonality and responsibility. The principles have proven to be very effective, with many companies adopting them since they have led to stable and highly consistent products and services. In general, the key success factors comprise clear determination of authorities, standardised rules, control, and responsibility. Such corporate culture examined by the OCAI questionnaire is referred to as "hierarchy." It is characteristic of its formalised and structured workplace emphasising procedures and regulations, where formal rules are the unifying element (Heritage et al., 2014). Leaders are good coordinators and organisers, for whom it is crucial to maintain the smooth functioning of the organisation, its stability and efficiency. Success is defined by reliability of supplies, continuous fulfilment of schedules and low costs. Employee management is aimed at ensuring job security (Cameron & Quinn, 2006).

At the end of the 1960s, companies began to face new challenges caused by growing competition, giving rise to "market" culture (Cameron & Quinn, 2006). In a hierarchical corporate culture, internal control is ensured through regulations, specialised job positions and centralised decision-making. Market corporate culture works on the economic market mechanisms and transactions. Its primary concerns involve realising transactions (exchanges, sales, and contractual obligations) with other participants in order to reach competitive advantages. The main objectives of market-oriented companies are the final results, their market power, set targets and reliable clients, while the core values are competitiveness and productivity. Leaders are ambitious competitors demanding a high level of performance from their subordinates, and the organisation is held together by orientation to its primacy. Long-term attention is being drawn to competitive activities and reaching overestimated goals. Success is defined by gaining market share and market penetration, and the emphasis is put on overtaking competition and achieving market leadership (Cameron & Quinn, 2005).

The third type of corporate culture is "clan" culture, named after its similarity to family-type businesses. It is a friendly working environment reminiscent of an extended family where people share the same values (Cameron & Quinn, 2006). Leaders take the role of teachers or counsellors (and occasionally parents), and such organisation is bound by loyalty, tradition, and high commitment (Jaeger et al., 2017). Individual goals are in line with corporate goals based on the individuals' trust in the respective enterprise (Jones & Madey, 2014). The long-term benefits of each person's development are emphasised, and great importance is attached to cohesion and morality (Demski et al., 2016; Übius & Alas, 2009). Success is perceived in connection with the internal environment and care for the people, while teamwork, participation and consensus are considered as paramount (Teräväinen et al., 2018).

A gradual shift from the industrial period to the information period laid foundations for the emergence of the fourth type of culture, being able to best respond to hyper-turbulent and constantly accelerating conditions that increasingly depict the world of the 21st century organisations. It is "adhocracy" corporate culture manifested by a dynamic and creative working environment (Jaskyte, 2014; Lau & Ngo, 2004). Employees are willing to perform at their own risk, and leaders are visionaries and innovators willing to take risks. The organisation is brought together by experimenting, innovative approaches and thinking. To be at the forefront of knowledge, products and services is seen as fundamental, and the readiness for changes and new challenges is appreciated. The long-term goal is to focus on rapid growth and acquiring new resources. Success consists in producing unique and original products and services (Cameron & Quinn, 2006).

2. Research methodology

The SMEs may be regarded as strategic in terms of their sectoral structure. They form a significant part of Slovakia's economy, with the greatest growth potential and impact on economic stabilisation and balanced regional development. The aim of the research

is to define effectiveness factors resulting from corporate culture applied in SMEs in Slovakia. A partical aim is to define the factors that affect business efficiency in 6 dimensions (dominant characteristics, organisational leadership, management of employees, organization glue, strategic emphases, and criteria of success), as follow:

i) Dominant characteristics – discover the principal features of the environment and atmosphere prevailing in the enterprise?

ii) Organisational leadership – identify what is understood as the leadership and leadership abilities?

iii) Management of employees – find out the nature of the managerial style and what methods are applied in management?

iv) Organisation glue – detect how the company consolidates itself?

v) Strategic emphases – determine the company goals and what is valuable?

vi) Criteria of success – to find how is success defined in the company?

It is assumed that there exist differences in factors that affect business efficiency of SEs and MEs from the perspective of corporate culture.

2.1 Data collection and sample

Since 2014, the corporate culture research has been running in Slovakia. The sociological research method through questionnaires was used. The questionnaires were distributed electronically via Google Docs. Since 2014, a database of enterprises from different industries was created. In this research, the data obtained from SMEs were used. A total of 3,524 respondents participated in the research. In total, 1,793 employees working in small enterprises (SEs) participated in the research. SEs are adopted as defined in EU recommendation No. 2003/361 with a number of employees below 50. A total of 1,731 employees working in medium-sized enterprises (MEs) participated in the research. MEs enterprises are adopted as defined in EU recommendation No. 2003/361 with a number of employees below 250.

The research is based on the online questionnaire as a research method to acquire empirical data. In order to acquire relevant data and to ensure the variability and randomness of respondent selection, randomly selected employees working in enterprises operating in Slovakia were asked to fill the questionnaires via Google Docs. The questionnaire was divided into two parts. The features of respondents (industry and type of enterprise the employee works for) were investigated in the first part. The second part of the questionnaire follows the Cameron and Quinn methodology, where a set of different factors that affect business efficiency is defined in six dimensions, i.e., dominant characteristics, organisational leadership, management of employees, organization glue, strategic emphases, and criteria of success (Cameron & Quinn, 2006). Each dimension is examined through four alternatives. Each alternative corresponds with one of the corporate culture types, which presents a set of different factors that affect business efficiency. Specifically, alternative A corresponds with clan culture. Alternative B corresponds with adhocracy culture. Alternative C corresponds with market culture, and alternative D corresponds with hierarchy culture. It total, there are 6 dimensions with 4 alternatives each, giving 24 alternatives together, investigating factors that affect business efficiency.

Respondents divided 100 points between alternatives according to the fact which of them are put into practice, e.g., alternative A = 60 points (the most similar to the enterprise), alternative B = 17.5 points and alternative C = 17.5 points (alternative B and alternative C are a bit similar), and alternative D = 5 points (almost dissimilar) (Cameron & Quinn, 2006). The methodology, developed by Cameron and Quinn (1999, 2006), involves the final stage, where average values of the alternatives from all six dimensions were calculated and the total average was defined. The outcome of the methodology is a type of corporate culture providing an overview of the set of different factors that affect business efficiency, which are put into practice (Cameron & Quinn, 2006).

2.2 Statistics methods

Results were processed by the statistical RStudio software. Alternatives of corporate culture were defined by estimated average values. The Beta regression method and the methods of inductive statistics were used. Interval estimates and Tukey's test were used, allowing multiple comparisons, assuming independence between factor levels, consistency variance, and normality, usually utilised to identify pairs of diameters that greatly differ from one another. The assumption that there are significant

differences in factors that affect the business efficiency of SEs and MEs from the perspective of corporate culture was tested. The significance level of 5% was used.

3. Research results

The set of different factors that affect business efficiency from the perspective of corporate culture was assessed in six dimensions. The results of the research are presented in box plots representing 95% confidence intervals for the estimated average values of the significance of corporate culture in SMEs. The existence of differences in SEs and MEs was tested. The existence was confirmed on the basis of p-value provided that $p < 0.05$.

3.1 Dominant characteristics

Based on the methodology by Cameron and Quinn (1999), the dominant characteristic was the first area analysed. Respondents assessed the set of different factors that affect business

Tab. 1: The dominant characteristics in SMEs

Alternative	Enterprise size	Estimated average (Beta regression)	Standard error	Confidence interval		Estimated average	Standard error	z-score	p-value
				−95%	95%				
Alternative A	SEs	0.363	0.00537	0.353	0.374	0.093483	0.00715	13.076	<0.0001
	MEs	0.270	0.00479	0.260	0.279				
Alternative B	SEs	0.218	0.00417	0.210	0.227	0.009036	0.00575	1.572	0.7670
	MEs	0.209	0.00413	0.201	0.217				
Alternative C	SEs	0.251	0.00453	0.243	0.260	−0.038685	0.00665	−5.819	<0.0001
	MEs	0.290	0.00497	0.280	0.300				
Alternative D	SEs	0.252	0.00454	0.243	0.261	−0.030784	0.00660	−4.661	0.0001
	MEs	0.283	0.00491	0.273	0.293				

Source: own

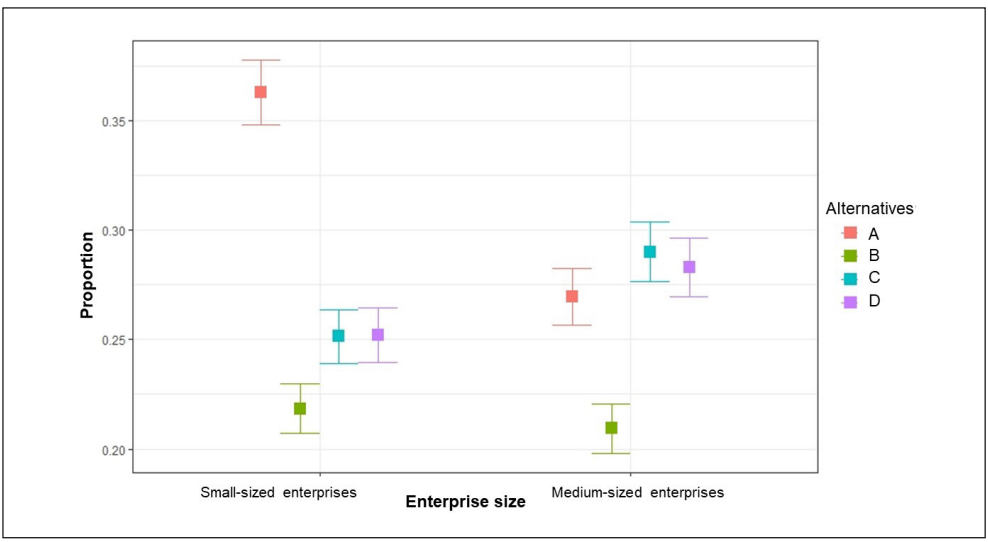

Fig. 1: The dominant characteristics in SMEs

Source: own

efficiency through individual alternatives according to the fact, which of factors that affect business efficiency mirrors the state-of-the-art most. The following factors were investigated:

- Alternative A: The company is like a family. It is a place, where people are enabled to share a lot of personal information and features.
- Alternative B: The company is a place for people to take risks. It is a dynamic entrepreneurial spot.
- Alternative C: The company focuses on results. A major concern is getting the job done. People are competitive and achievement oriented. They like to get the job done.
- Alternative D: The company is structured with a strong control. Employees are managed by formal instructions.

Following the results of the research from Tab. 1 and Fig. 1 based on the OCAI methodology in the first research dimension of dominant characteristics, it can be stated that alternative A dominated in the SEs, achieving the highest average rating ($\hat{X}$ = 0.363). The respondents perceive the enterprises as family-based, where people have a lot in common.

Alternative C ($\hat{X}$ = 0.290; p < 0.0001) dominates in the MEs. Following the results, it can be stated that MEs are oriented to meeting goals and tasks. However, respondents working in MEs perceive the corporate culture through alternative D (alternative D; $\hat{X}$ = 0.283; p < 0.0001) and alternative A (alternative A; $\hat{X}$ = 0.270; p < 0.0001), too. From the point of view of respondents, MEs are perceived as controlled (alternative D) where employees have a lot in common (alternative A) as well.

Following the results presented in Tab. 1, the existence of differences in the SEs and the MEs in alternative A and alternative C was confirmed.

3.2 Organisational leadership

In terms of organizational leadership as the second dimension studied, respondents evaluated the alternatives according to the fact, which of the factors that affect business efficiency are put into practice, and which of them mirrors the state-of-the art most:

- Alternative A: The leadership style in the company is recognised as facilitating, mentoring or nurturing.
- Alternative B: The leadership style is generally considered as focused on business acumen, innovation and risk taking.
- Alternative C: The leadership in the company is like an aggressive with strong focus on results and goals.
- Alternative D: The leadership is typical by spontaneous efficiency and coordination.

Tab. 2, and Fig. 2 present that alternative A dominates the SEs ($\hat{X}$ = 0.330), where managers are seen as mentors. Alternative D ($\hat{X}$ = 0.309) is typical for MEs. Leadership is collaborative and organised. Statistically significant differences in the SEs and the MEs (p < 0.0001) were confirmed in alternative A. No differences were confirmed in alternative D (p = 0.1621).

3.3 Management of employees

Management of employees was the third dimension analysed. The factors that affect

Tab. 2: The organizational leadership in SMEs

Alternative	Enterprise size	Estimated average (Beta regression)	Standard error	Confidence interval		Estimated average	Standard error	z-score	p-value
				−95%	95%				
Alternative A	SEs	0.330	0.00531	0.319	0.340	0.09250	0.00691	13.377	<0.0001
	MEs	0.237	0.00455	0.228	0.246				
Alternative B	SEs	0.255	0.00467	0.246	0.264	−0.00186	0.00657	−0.283	1.0000
	MEs	0.257	0.00477	0.248	0.266				
Alternative C	SEs	0.207	0.00410	0.199	0.215	−0.04066	0.00609	−6.673	<0.0001
	MEs	0.248	0.00466	0.238	0.257				
Alternative D	SEs	0.291	0.00500	0.281	0.300	−0.01855	0.00718	−2.583	0.1621
	MEs	0.309	0.00525	0.299	0.319				

Source: own

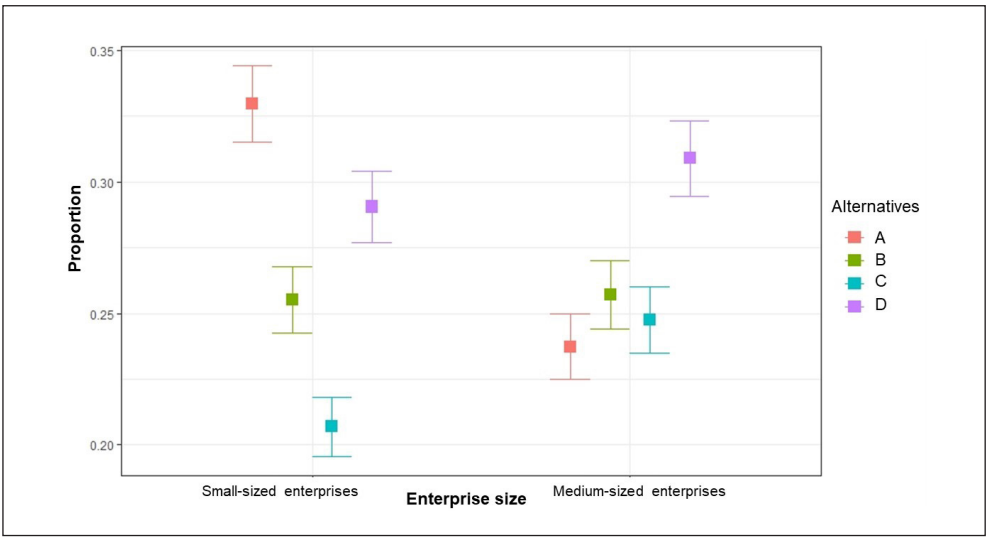

Fig. 2: The organizational leadership in SMEs

Source: own

business efficiency were investigated through the following alternatives:

- Alternative A: The management style can be recognised by cooperation, teamwork and engagement.
- Alternative B: The company management style is typical as risk taking, innovating and unique.
- Alternative C: The management style in the company represents competitiveness, high demands, and achievement.
- Alternative D: The company management style is characterised by relationship stability, high level of predictability and security of employment.

Based on the results presented in Tab. 3 and Fig. 3, we can be state that the factors typical for alternative A came on top in both types of enterprises (the SEs, $\hat{X}$ = 0.397; the MEs, $\hat{X}$ = 0.314). Teamwork and cooperation are the factors that affect business efficiency from

Tab. 3: The management of employees in SMEs

Alternative	Enterprise size	Estimated average (Beta regression)	Standard error	Confidence interval		Estimated average	Standard error	*z*-score	*p*-value
				−95%	95%				
Alternative A	SEs	0.397	0.00554	0.386	0.408	0.08243	0.00755	10.915	<0.0001
	MEs	0.314	0.00518	0.304	0.325				
Alternative B	SEs	0.214	0.00413	0.206	0.222	−0.00707	0.00583	−1.213	0.9285
	MEs	0.221	0.00428	0.213	0.230				
Alternative C	SEs	0.203	0.00398	0.195	0.211	−0.02155	0.00576	−3.743	0.0045
	MEs	0.224	0.00432	0.216	0.233				
Alternative D	SEs	0.261	0.00464	0.252	0.270	−0.02381	0.00670	−3.554	0.0091
	MEs	0.285	0.00494	0.275	0.295				

Source: own

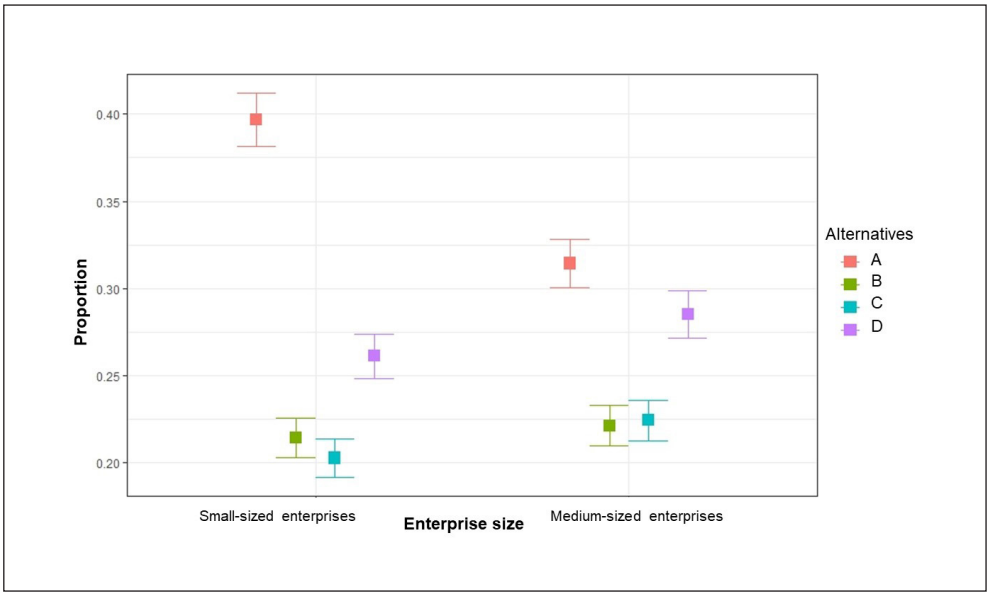

Fig. 3: **The management of employees in SMEs**

Source: own

the perspective of corporate culture. Even though the highest rating was reported for alternative A, the existence of differences in the SEs and the MEs was confirmed.

3.4 Organisation glue

Organisation glue was the fourth dimension of corporate culture studied. Respondents evaluated the alternatives according to the fact, which of the factors that affect business efficiency are put into practice. The alternatives of this dimension state that the organisation glue that holds the company together is:

- Alternative A: the commitment to the company and high engagement of people.
- Alternative B: the commitment to innovation and development. There is an accentuation on pioneer progress.
- Alternative C: the focus on achievement and reaching the company goals.
- Alternative D: formal policies and regulations. The guarantee of a smooth-running company is important.

Following the research results presented in Tab. 4 and Fig. 4, it can be stated that employees of the SEs are unified by loyalty, mutual trust and dedication, i.e., alternative A dominates ($\hat{X}$ = 0.341). The highest rating for the MEs was reached by alternative C ($\hat{X}$ = 0.301), which emphasises accomplishing enterprise goals, followed by alternative D ($\hat{X}$ = 0.297), focused on maintaining the trouble-free functioning of all enterprise processes. The existence of differences in the SEs and the MEs in alternative A and alternative C was confirmed. No differences were confirmed (p = 0.4999) in alternative D.

3.5 Strategic emphases

The dimension of strategic emphases was the fifth dimension analysed. The set of different factors that affect business efficiency, which is put into practice, were analysed:

- Alternative A: The company underline openness, high confidence and people development.
- Alternative B: The company accent new talent acquisition and supports looking a new opportunities and challenges.
- Alternative C: The company point out competitiveness and related achievement. To be a winner in business is the company precedence.

Tab. 4: The organization glue in SMEs

Alternative	Enterprise size	Estimated average (Beta regression)	Standard error	Confidence interval		Estimated average	Standard error	*z*-score	*p*-value
				−95%	95%				
Alternative A	SEs	0.341	0.00522	0.331	0.351	0.07753	0.00697	11.117	<0.0001
	MEs	0.263	0.00471	0.254	0.273				
Alternative B	SEs	0.211	0.00406	0.203	0.219	0.00267	0.00565	0.473	0.9998
	MEs	0.208	0.00410	0.200	0.216				
Alternative C	SEs	0.247	0.00447	0.238	0.256	−0.05376	0.00666	−8.076	<0.0001
	MEs	0.301	0.00504	0.291	0.311				
Alternative D	SEs	0.283	0.00481	0.274	0.293	−0.01356	0.00687	−1.974	0.4999
	MEs	0.297	0.00500	0.287	0.306				

Source: own

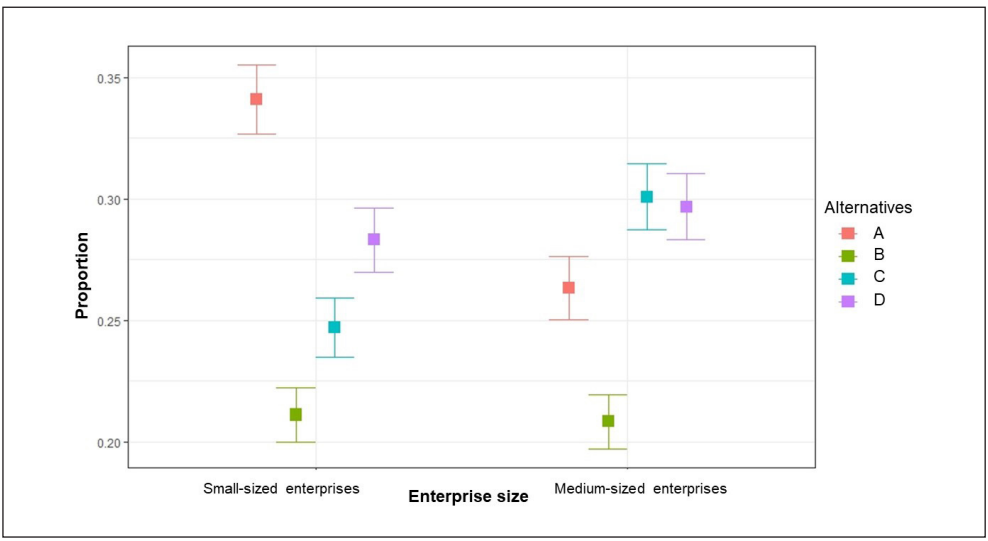

Fig. 4: The organization glue in SMEs

Source: own

- Alternative D: The company stress on efficient stability and control. Permanent smooth processes management is in place.

The SEs are clearly directed at human resource development ($\hat{X}$ = 0.333). Alternative A is typical (Tab. 5, Fig. 5). Alternative D ($\hat{X}$ = 0.282) encompassing emphases on stability, performance, control, and operability dominates MEs, followed by alternative C ($\hat{X}$ = 0.276), linked to achieving long-term goals, and followed by alternative A ($\hat{X}$ = 0.268), encompassing human resource development but also trust and cooperation. Statistically significant differences were confirmed (Tab. 5).

3.6 Criteria of success

Finally, criteria of success was the last dimension studied. Respondents evaluated each

Tab. 5: The strategic emphases in SMEs

Alternative	Enterprise size	Estimated average (Beta regression)	Standard error	Confidence interval		Estimated average	Standard error	*z*-score	*p*-value
				−95%	95%				
Alternative A	SEs	0.333	0.00518	0.323	0.343	0.06514	0.00697	9.341	<0.0001
	MEs	0.268	0.00476	0.259	0.277				
Alternative B	SEs	0.238	0.00437	0.229	0.246	0.00761	0.00607	1.254	0.9155
	MEs	0.230	0.00436	0.222	0.239				
Alternative C	SEs	0.235	0.00434	0.226	0.243	−0.04146	0.00640	−6.473	<0.0001
	MEs	0.276	0.00483	0.267	0.286				
Alternative D	SEs	0.272	0.00471	0.262	0.281	−0.01070	0.00671	−1.594	0.7542
	MEs	0.282	0.00489	0.273	0.292				

Source: own

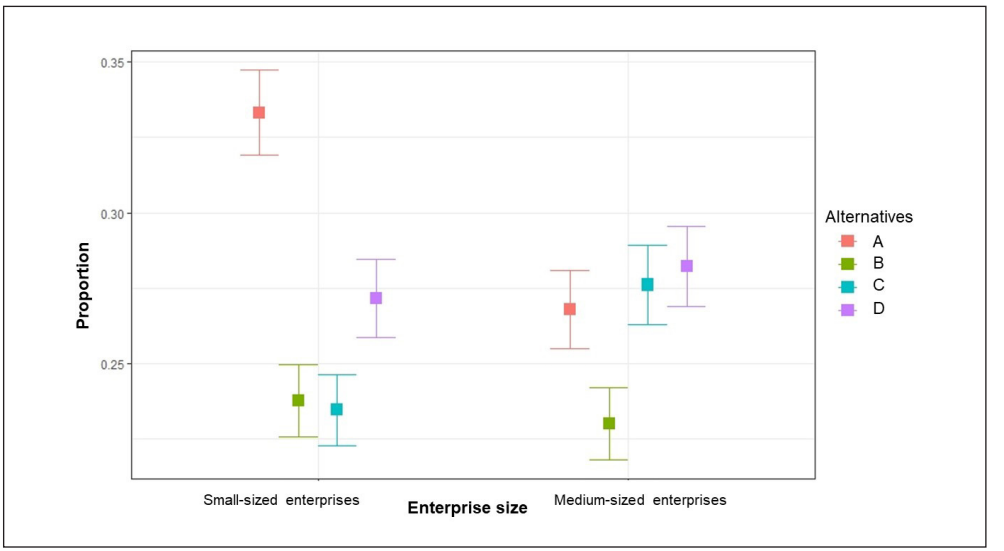

Fig. 5: The strategic emphases in SMEs

Source: own

alternative according to the fact, which of them mirrors the success definition:

- Alternative A: The company defines success with strong focus on people. Teamwork, human resources development and employee engagement are valuable.
- Alternative B: The company defines success through products. Innovative, unique and new products are the most important.
- Alternative C: The company defines success based on product market. Leading the market and having a competitive advantage are the goals.
- Alternative D: The company defines success on the basis of efficiency. Cost effective production processes and precise scheduling and budgeting are critical.

Tab. 6: The criteria of success in SMEs

Alternative	Enterprise size	Estimated average (Beta regression)	Standard error	Confidence interval		Estimated average	Standard error	*z*-score	*p*-value
				−95%	95%				
Alternative A	SEs	0.371	0.00559	0.360	0.382	0.06278	0.00764	8.219	<0.0001
	MEs	0.308	0.00527	0.297	0.318				
Alternative B	SEs	0.238	0.00451	0.229	0.247	0.01285	0.00620	2.073	0.4325
	MEs	0.225	0.00443	0.217	0.234				
Alternative C	SEs	0.228	0.00439	0.220	0.237	−0.02945	0.00640	−4.602	0.0001
	MEs	0.258	0.00480	0.248	0.267				
Alternative D	SEs	0.264	0.00479	0.255	0.273	−0.01368	0.00683	−2.001	0.4808
	MEs	0.278	0.00500	0.268	0.287				

Source: own

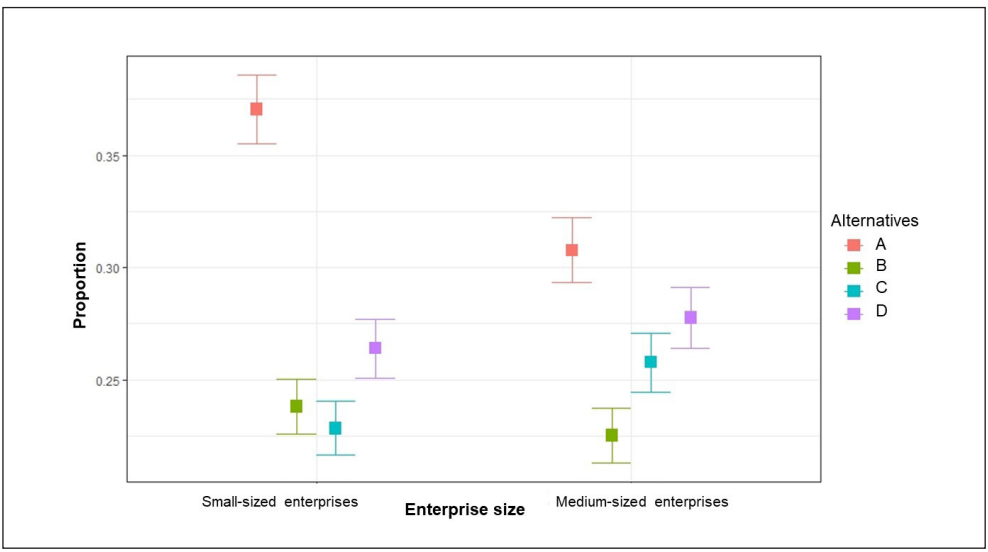

Fig. 6: The criteria of success in SMEs

Source: own

Following the results of the research from Tab. 6 and Fig. 6, it can be stated, that alternative A dominates in both types of enterprises (the SEs, $\hat{X}$ = 0.371; the MEs, $\hat{X}$ = 0.308). Human resource development and teamwork are the factors that affect business efficiency from the perspective of corporate culture in SEs and MEs. Statistically significant differences were confirmed in alternative A (p < 0.0001).

3.7 Corporate culture

Subsequently, in the final stage, a type of corporate culture giving an overview of the set of different factors that affect business efficiency, which are put into practice, was analysed. Results are presented in Tab. 7 and Fig. 7.

Tab. 7 and Fig. 7 present the results reached in a type of corporate culture. Based on the results, it can be stated that in SEs a set

Tab. 7: The corporate culture in SMEs

Corporate culture	Enterprise size	Estimated average (Beta regression)	Standard error	Confidence interval		Estimated average	Standard error	*z*-score	*p*-value
				−95%	95%				
Clan	SEs	0.339	0.00329	0.333	0.346	8.02e-02	0.00447	17.940	<0.0001
	MEs	0.259	0.00305	0.253	0.265				
Adhocracy	SEs	0.207	0.00271	0.201	0.212	9.43e-05	0.00384	0.025	1.0000
	MEs	0.207	0.00276	0.201	0.212				
Market	SEs	0.214	0.00275	0.208	0.219	−4.70e-02	0.00409	−11.499	<0.0001
	MEs	0.261	0.00305	0.255	0.267				
Hierarchy	SEs	0.261	0.00300	0.255	0.266	−2.17e-02	0.00433	−5.016	<0.0001
	MEs	0.282	0.00315	0.276	0.288				

Source: own

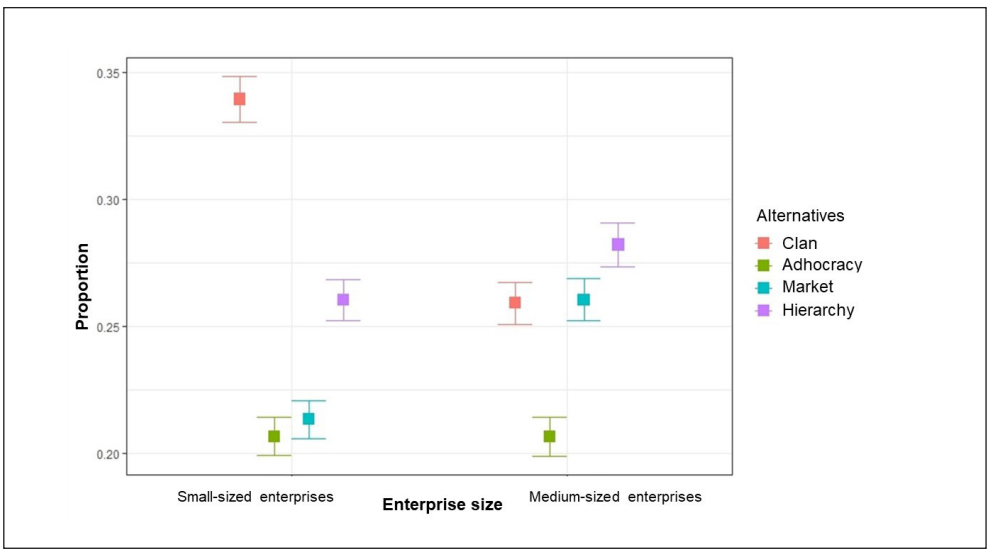

Fig. 7: The corporate culture in SMEs

Source: own

of different factors typical for clan corporate culture affects business efficiency ($\hat{X}$ = 0.339). Teamwork, participation, communication, and consensus represent factors that affect business efficiency from the perspective of clan corporate culture in SEs. Emphases are placed on coherence, morale, and the working environment. Managers are considered mentors, and employee management is oriented towards teamwork and cooperation. Employees are held together by loyalty, mutual trust, and dedication to the respective enterprise. Its overall business performance and success are based on human resource development and teamwork.

Conversely, factors typical for hierarchy corporate culture affect business efficiency in MEs ($\hat{X}$ = 0.282). Emphasis is placed on keeping

the organisation functioning continuously, as well as on the predictability, efficiency, and accuracy of management processes. Leaders are good coordinators and organisers, while it is crucial for them to keep the smooth functioning of the organisation, its stability and efficiency. Management of employees is focused primarily on ensuring job security, with formal rules being the unifying element. The overall business performance and success are defined by supply reliability, continuous fulfilment of schedules and low costs.

In the final stage, the differences in the type of corporate culture in SEs and MEs were tested. Results are presented in Tab. 7 and Fig. 7. Statistically significant differences in clan corporate culture ($p < 0.0001$) and hierarchy corporate culture ($p < 0.0001$) were observed.

Conclusions

Following the research results, it can be stated that the assumption that there exist differences in factors that affect the business efficiency of SEs and MEs from the perspective of corporate culture was confirmed. The findings correspond with the results of several other research, e.g., Arsenault (2004), Carver and Candela (2008), Bauerlein (2009), De Waal et al. (2017), and Striteska and Zapletal (2020), where differences in views on corporate culture have been identified.

A set of different factors typical for clan corporate culture affects business efficiency in SEs. Teamwork, participation, communication, and consensus represent factors that affect business efficiency from the perspective of clan corporate culture in SEs. The employees share common ideas and see themselves as part of company family that really works. The working environment is reminiscent of an extended family, where equal opportunities for people as well as diversity in the workplace are created. Leadership has different forms of mentoring, and leaders play the role of teachers, advisors, or even parents. Individual goals are in line with corporate goals based on the individuals' trust in the respective enterprise, employee commitment is high, and a sense of unity is conditioned by loyalty and tradition. Also, the long-term benefits of each person's development are emphasised, great importance is attached to cohesion, morality and the working environment, and success is seen in relation to the internal environment and caring for the people (Cameron & Quinn, 1999). Our outputs are confirmed by previous research (Cucek & Kac, 2020; Demski et al., 2016; Ibarra-Michel et al., 2019; Jones & Madey, 2014; Teräväinen et al., 2018), which show an orientation towards factors typical for clan corporate culture.

Factors typical for hierarchy corporate culture affect business efficiency in MEs. Particular stress is being laid on procedures, regulations, and internal sustainability, along with the need for stability and control. Regulations and order ordinarily become the core values, while leadership is based on organised coordination and monitoring. Emphasis is placed on keeping the organisation functioning continuously, as well as on the predictability, efficiency, and accuracy of management processes. Preferred values involve consistency and uniformity, top-down communication prevails, and standardisation is typical. Similar outcomes were presented in previous research (Balogh et al., 2011; Caliskan & Zhu, 2019; Jaeger & Adair, 2013; Matraeva et al., 2016; Matraeva et al., 2018). Hierarchy culture was found to be dominant among construction organisations in China (Jaeger et al., 2017), as well as among the Gulf Cooperation Council countries (Jaeger & Adair, 2013).

Corporate culture is still an interesting research topic for researchers and practitioners (Calderon et al., 2023; Cruz et al., 2022; Petrova et al., 2023). Corporate culture can work synergistically for the benefit of a particular enterprise and "glue" its employees together by creating a working environment that is instrumental in improving the enterprise and its sustainability while helping to innovate and change it. The purpose of the paper was to define the factors that affect business efficiency from the perspective of corporate culture in SMEs in Slovakia. It adds to the existing gap by providing different factors that affect business efficiency from the perspective of corporate culture in SMEs in Slovakia. The research is intended for managers who must know which factors affect business efficiency from the perspective of corporate culture. Managers must take into account the fact that differences exist in factors that affect the business efficiency of SEs and MEs from the perspective of corporate culture. Research results lead to the knowledge that effectiveness factors typical for clan corporate culture, such as teamwork, communication, loyalty, and human resource development, are

applied in SEs operating in Slovakia. However, MEs are dominated by hierarchy corporate culture with an emphasis on regulations, procedures, stability, control, and accuracy of management. According to our opinion, clan culture is the best type of corporate culture for SMEs operating in Slovakia mainly due to its interest on employees. Our outcomes are confirmed in the research provided in the Czech Republic (Mikusova et al., 2023) and Romania (Cosmin et al., 2021), where employees would prefer clan culture, more specifically, a place where people share the same values, and loyalty and traditions are key for a friendly work environment. Clan corporate culture is also preferred by the employees in the research of Strengers et al. (2022). Therefore, it is recommended to put the emphasis on the development of each person because employees represent a strategic tool which can influence the effectiveness of all business processes. Managers should focus on employees who, on the one hand, are the most expensive production factor, but on the other hand, can influence the effectiveness of all business processes. Human resources are the most important element within an enterprise since how work or tasks are carried out is likely to affect the given enterprise, its success, and its competitive advantage. Our conclusions are supported by the research of Fernandes et al. (2023), Smith (2020), and Vnouckova et al. (2015), who point out the importance of employees in the overall performance of the enterprise and a competitive differential as they are the persons who dispose of skills and experience and they are the sources of new ideas. Also, according to Lee and Ha-Brookshire (2018) the success of any company essentially depends on the performance of its employees, in that they make an effort beyond what is expected of them in the workplace. The research of Al-Madadha et al. (2021) adds that this is especially true at present, given the dramatic changes in the economic environment, constant improvements in technology, and the extent of heated competition in the marketplace. If the management of the enterprise can draw attention to employees, their innovative ideas, abilities and skills, which create and build value, we can expect the enterprise to achieve overall success and a competitive advantage.

Future direction of the research of corporate culture can be seen in defining different factors that affect business efficiency from the perspective of corporate culture in large-sized enterprises. Emphases will be placed on observing how the COVID pandemic affected corporate culture.

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DuPont analysis among European dentistry companies to measure the impact of the COVID-19 pandemic

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Abstract: *Although health economics belongs to the highly respected economic disciplines within the research literature, there is a considerable gap related to the investigation of dentistry in particular, even after the global pandemic of COVID-19 disease. Fundamentally, the DuPont framework is a well-known complex analysis to evaluate companies from the point of view of financial performance. The investigation of the return on equity as a relation between the return on assets and the equity multiplier, simply called the leverage effect, is presented in this paper. Therefore, this study aims to estimate the effect of leverage and its changes due to the COVID-19 pandemic among dentistry companies in selected European countries with different healthcare insurance systems. This comparative investigation focused on the generalised method of moments with dynamic panel data from Orbis, the Bureau van Dijk financial database for 1,128 dentistry companies in nine European countries. Methodologically, concerning those post-estimation techniques to evaluate over- and underestimation of the models. It has been differentiating between companies with a high or low ownership concentration structure. The results have shown differences in the leverage effect during the pandemic, assuming that companies with a major owner increased their equity, while the debt leverage increased among those companies with dispersed ownership and vice versa. If economic theory states that debt financing is more effective for a company than using internal sources, it is apparently different in the case of dentistry during the pandemic. However, dispersed ownership is more often related to dentistry, according to mergers in this particular business industry.*

Keywords: *Financial performance, debt leverage, health economics, healthcare systems, concentration of ownership structure.*

JEL Classification: *G32, I11, M21.*

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Introduction

DuPont analysis is one of the oldest frameworks for fundamentally evaluating a company. However, no one has ever used that, even partially, to estimate the impact of the COVID-19 pandemic on company performance. Although Chang et al. (2014) used the DuPont framework within the health economics already. The pandemic is generally considered the main cause of economic downturn among many industries in 2020 and 2021, and dentistry is not an exception (Patel, 2020). The question also is whether the healthcare system itself, either Beveridge or Bismarck model investigated throughout

the literature (Deppe & Oreskovic, 1996; Lameire et al., 1999; Marmor & Okma, 1997; Wendt, 2009; Widström & Eaton, 2004), could have somehow affected the situation among those dentistry companies during the pandemic. Based on the literature in the next section, three different research questions motivate this study: i) Since every human being living in a developed economy is somehow related to dentistry as a patient, did the COVID-19 changes caused by the pandemic vary across countries with a different health care system? (i.e., Beveridge vs. Bismarck); ii) Even though the DuPont framework is a crucial part of the fundamental analysis, could it be helpful to estimate the impact of the pandemic on dentistry?; and iii) Is the trend of mergers obvious among dentistry companies even during the affected period?

Focused on the Dupont analysis, this paper aims to estimate the leverage effect and its changes due to the COVID-19 pandemic among dentistry companies in selected European countries having either the Beveridge model (National Health Service System) or the Bismarck model (Compulsory Universal Health Insurance System). For the empirical part of this paper, DuPont analysis, essentially evaluating a breakdown of profitability and commonly even within health economics (Chang et al., 2014; Turner et al., 2015), has been deployed, according to Soliman (2008). Therefore, using this particular technique, individual influences that affect the final value of profitability ratios have been investigated (Doorasamy, 2016; Fairfield et al., 1996, 2009; Nissim & Penman, 2001). Furthermore, an investigation of dentistry companies with a high concentration of ownership has a major owner compared to those with a low concentration and dispersed ownership is carried out. The contribution of this study is also methodological, testing up-to-date post-estimation techniques while using the system-generalised method of moments with longitudinal data.

This paper is structured as follows. As mentioned above, Section 1 briefly reviews the literature related to health economics. The methodology and data are described in Section 2. A discussion of GMM estimates is made in Section 3 of this paper, right before its conclusion.

1. Theoretical background

It is important for the economies of individual countries that people can work and be active in the labour market. To be able to be, they must be healthy. Therefore, it is necessary to be aware of this at the highest levels of individual economies. Oral health is also related to the issue of health. Oral health, along with growing awareness of the impact that limited dental coverage has on oral health and overall health and well-being, has received increased attention in recent years (Winkelmann et al., 2022). Therefore, it is necessary to pay considerable attention to the area of oral healthcare providers and to support dentistry and related fields. Therefore, attention should be paid both to dentists but also to various fields of providers and producers of services in the field of oral health care. According to Peres et al. (2019), the personal consequences of chronic untreated oral diseases are often severe and can include unrelenting pain, reduced quality of life, lost school days, disruption of family life, and reduced work productivity. The cost of treating oral diseases represents a large economic burden on families and healthcare systems (Bawaskar & Bawaskar, 2020). Oral diseases are undoubtedly a global public health problem, with particular concern over their increasing prevalence in many low- and middle-income countries linked to wider social, economic, and commercial changes (Peres et al., 2020).

It is also important to monitor certain socioeconomic inequalities in the health of the population (Do et al., 2010). Inequality in oral health is expected due to the growing socioeconomic inequality of people, and this has a direct impact on the functioning of dental businesses. In countries where socioeconomic differences are more pronounced, inequality in the area of oral health is also more pronounced (Do et al., 2010; Elani et al., 2012; Garcia & Tabak, 2011; Hosseinpoor et al., 2012). An interesting approach can be observed in the study of Pinilla and González (2009), which traces the relationships between dental health and the use of dental care with socioeconomic factors, human resources, and the financing and organisation of dental care systems in European countries. However, Pinilla and González (2009) found no evidence that better access (a policy aimed at improving access to oral health services) to dentists improved dental health in 12-year-old children. The main parameters that influence oral health and its development are income and level of education within countries. A higher number of dentists and a relatively young adult

population have a positive effect on the use of dental services.

The importance of providing dental medical care is clearly defined. For this, it is necessary to state that everything is related to finance. And the field of dentistry is very specific from the point of view of financing. Different approaches to the provision of publicly available dental care or elements thereof are adopted (Widström & Eaton, 2004). In general, it can be said that the expenditure on dental care is financed from several sources, i.e., from public sources and direct payments from households (Bailit & Beazoglou, 2008). Public resources are related to the health systems established in a given country. In Europe, there are two types of healthcare systems used. They are the Beveridge model and the Bismarck model. The Beveridge model is built on the principle of health care paid for through redistributive processes in the economy and thus from taxes (Lameire et al., 1999; Wendt, 2009). The Bismarck model is based on universal health insurance and health care is covered by public health insurance, which is mandatory (Deppe & Oreskovic, 1996; Marmor & Okma, 1997; Wendt, 2009). These two models are the basis of healthcare in European countries. So, it follows that medical dental care in European countries is partly paid for either from collected taxes or through insurance companies. But it is still true that in almost all countries, dental care is financed to a greater extent by private patient payments than in other sectors of health care (Widström & Eaton, 2004).

Funding in the field of dental care is highly debatable, with constantly changing attitudes in different countries, which can also affect the dental businesses themselves. In most countries, dental care is only partially covered by public health insurance, which can also have a certain impact on the general oral health of residents and households. On the negative impact of insufficient funding from public health insurance funding (Ahmadi et al., 2021). A study has been carried out that suggests that financing health care through households' direct finances results in "catastrophic health expenditure" and impoverishment of the population and their health in many countries. Liu et al. (2019) explain that, in general, catastrophic health expenditures represent out-of-pocket payments that exceed a specified threshold of household income or household ability to pay. The findings of this study (Ahmadi et al., 2021) stated that dental services are the basis of catastrophic health expenditures, and these services must be covered to a greater extent by basic health insurance or from other public sources.

Another area that is gradually coming to the fore and is beginning to affect the financial stability of dental businesses is the pressure on the ecological sustainability of dental practice (Duane et al., 2019). Therefore, the area of sustainable dentistry is gaining importance. Duane et al. (2020) mention the global commitment to sustainability, and the fact remains that the demands for a sustainable world are growing. Within dentistry, it is possible to monitor the possibilities of improving the sustainability of the environment in several areas. The biggest burden is travelling to the dental office, which is often outside the patient's region, and this results in a further increase in carbon emissions, which also contributes to damage to human health. Other areas are materials and devices for dental practice. Larger dental organisations can influence their suppliers by choosing environmentally friendly products from sustainable companies. However, this is another area that can place a greater financial burden on dental companies. Currently, dentistry is also recovering from the effects of COVID-19. Pandemic and individual pandemic measures have greatly affected dental businesses (Patel, 2020).

The dental profession is gradually changing in all directions (Samson & Schwartz, 2019). Historically, dentists were largely owners of their businesses. Another option was to join an older dentist with a vision of buying the office in the future. The problem was a lack of knowledge of how to handle the management of one's business. There was a lack of basic knowledge in the field of business economics. Over time, a new trend emerged when larger groups of businesses were founded to which dentists belong. It is easier for these dentists to take over the concept of managing and managing their business. Levin (2003) mentions that dentists often struggle with dealing with the business side of their practices. With a better understanding of the business aspects, it is possible to redirect energy and create a successful practice while performing excellent dentistry.

The dentists' approach to their profits, which they achieve by providing care and subsequent payment from both sources, is also related to the financing and expansion of

the care they provide or the improvement of the quality of care. The goal of every entrepreneur is to make a profit and it is no different for private dental centers. It is then important to consider how to deal with the profit achieved. Demirbag et al. (2015) claim that the reinvestment of profits back into the business is the key to success. Reinvestment is described by Cull and Xu (2005) as the percentage of profit invested back into the company. McCarthy et al. (1993) state that it is a decision to expand an existing business. Variables that, according to Demirbag et al. (2015), are relevant to the extension of a firm's lifespan include factors for which reinvestment may be key, and these are a scale of operation (Bercovitz & Mitchell, 2007), resource utilisation (Bercovitz & Mitchell, 2007; Bradley et al., 2011) and strategy growth (Mata & Portugal, 2002).

Financial management and reinvestment decisions are particularly specific if the company has a different owner and manager (Coles et al., 2001). The OLS results suggest that ownership is significant for firm performance, but when endogeneity is taken into account, ownership is not statistically dependent on performance measures (Welch, 2003). Berle and Means (1932) were one of the first to deal with the relationship between a firm's ownership structure and its performance. He argues that as ownership diffusion increases, shareholders become powerless to control professional managers. He further argues that since the interests of management and shareholders are generally not aligned, corporate resources are not used efficiently in maximising corporate profits.

The size of the company can also be decisive in the decision to reinvest part of the profit back into the business. Small and medium-sized enterprises are likely less interested in reinvesting profits in their business. As Wellalage and Reddy (2020) say, the reinvestment of profits back into the business is affected by the presence of weak rules and regulations, a weak organisational and institutional environment, and a highly uncertain business environment. These aspects also make SME owners reluctant to reinvest profits into their businesses. Furthermore, there are different approaches to using profit for your business. Caselli and Negri (2021) present the pecking order theory, which states that companies prioritise their sources of financing and consider equity financing as a last resort. This theory states that businesses follow a hierarchy of funding sources. First, internal funds are used, and when they are used, the loan option is used. Only when it is not possible to take another loan, the equity is used. Berger and Udell (1998) say that the hierarchy of financing used depends on the size of the firm and the level of development because, for each stage of growth, there is a certain level of information asymmetry and financing needs. This is also known as the "financial growth cycle."

Most dentists enjoy the clinical aspects of the dental practice but often find managing business systems and staff challenging. It is understandable. Most dentists lack business management training. The problem is that dentists train for several years in the practice of dentistry and then are thrown into the business environment without any specific business training (Levin, 2003). Dentists who run their practice must also consider how to approach earnings management, whether they will also use the reinvestment option. As part of the approach to the reinvestment of profits in one's business, it is also possible to observe a different approach from the point of view of the size of the enterprises. It can be assumed that small and medium-sized companies will tend to reinvest less than large enterprises. There may also be a difference in approaches to reinvestment within Europe. Dental businesses in Central and Eastern Europe are likely to be rather small and medium-sized. Wellalage and Reddy (2020) also mention in their article that SMEs reinvest profits in their business less. Different approaches to reinvestment, but also the form of dental businesses between the countries of Western Europe and the countries of Central and Eastern Europe, are not the only ones. Differences in other health areas are also evident. This difference is also addressed by Kolossváry et al. (2021). Thirty years after the transition period, starting in 1989, the countries of Central and Eastern Europe, representing one-fifth of the entire European population, share many historical, social, political, economic, and cultural characteristics. There is still a significant gap between Central and Eastern European countries and West European countries. Kolossváry et al. (2021) report that differences in risk factors and peripheral vascular care across Europe appear to be tangible and can be considered a signal of existing differences. Improvements in research and the development and cross-border sharing of scientific data are

essential to initiate and facilitate convergence in this area.

The difference in dentistry's approach to reinvesting profits into its business can also be seen across the healthcare systems used in a given country. The two aforementioned healthcare systems are used in the European Union. The Beveridge model (National Health Service System) is used by 12 EU countries: Denmark, Finland, Cyprus, Estonia, Greece, Ireland, Italy, Latvia, Malta, Portugal, Spain, and Sweden. The Bismarck model (Compulsory Universal Health Insurance System) is used by 15 EU countries: Austria, Belgium, Bulgaria, Croatia, Czech Republic, France, Germany, Hungary, Lithuania, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia. In other selected European countries (i.e., Great Britain and Norway) that are tested but are not part of the EU, the Beveridge model of the healthcare system is used.

Last but not least, in this particular case, according to Soliman (2008), DuPont analysis decomposes return-on-net-operating-assets (RNOA) into two multiplicative components, i.e., profit margin and asset turnover. Both are influenced by their affiliation to the industry. The use of DuPont analysis is also possible in the area of health economics data. This is also solved by Turner et al. (2015), who analyse the profitability of hospitals and, for these purposes, state that it is also possible to use DuPont analysis. This analysis is used to assess the quality of the income. By breaking down return on equity into profit margin, total asset turnover, and capital structure, DuPont's analysis reveals what drives overall profitability. Turner et al. (2015) find that investor-owned hospitals have larger profit margins, higher efficiency, and are more leveraged. Doorasamy (2016) also positively evaluated the DuPont analysis by pointing out that stock market volatility makes investment decisions controversial. Investing a certain amount of money requires a proper analysis to make the necessary decision. DuPont analysis can contribute to this. Profit breakdown is important for assessing profitability, and, further, a classification scheme improves profitability forecasts as well (Fairfield et al., 1996). Fairfield et al. (2009) mention that using an analytical model can improve performance prediction. An important finding is also that individual components of income can reveal significant impacts on industry, even though this is not evident in overall profitability. Nissim and Penman (2001) also write about the elements of the necessary accounting information and the breakdown for a better forecast of profitability. In their study, Chang et al. (2014) also draw attention to the issue of using DuPont analysis for the healthcare sector. They say DuPont components are less informative accounting signals in healthcare compared to the industry-wide sample. Analysts say that the monitoring of the healthcare sector should focus on changes in profit margins rather than changes in asset turnover. Only then will the accuracy of profitability forecasts be improved. According to Soliman (2008), in practice, the use of financial ratio indicators adjusting the industry is less frequent, and a large part of research on the average return of profitability assumes whole-economy reversal goals.

2. Research methodology

Just to explain what DuPont analysis is focused on, the main relations are described by the next two equations (Chang et al., 2014; Soliman, 2008). The return on equity (ROE) using the earnings after tax (EAT) of *i* companies (excluding those with negative equity) in time *t* is described in Equation (1) as follows:

$$ROE_{it} = \frac{EAT_{it}}{Equity_{it}} \times 100 \quad (1)$$

To measure how effectively assets are used in dentistry, the return on assets (ROA) using earnings before interest and tax (EBIT) is described in Equation (2):

$$ROA_{it} = \frac{EBIT_{it}}{Total\ assets_{it}} \times 100 \quad (2)$$

Nevertheless, to estimate the leverage effect within ROE and the turnover of assets within ROA, the generalised method of moments (GMM) is used. The use of GMM when working with panel data is justified especially when working with a dynamic panel, when the delayed, explained variable on the right-hand side of the equation is also statistically significant, the observed period to estimate the regression coefficients is shorter ($T \leq 10$), but the cross-section of the panel includes a larger number of companies. Because of the generalisation of the method of moments, the problem of heteroscedasticity of the residual component

is also solved when using the two-phase model. The method itself was constructed in their work by Anderson and Hsiao (1981) and subsequently by Hansen (1982) and further extended by Hansen et al. (1996). However, Arellano and Bond (1991) also contributed to its development by pointing out the problem of serial correlation of the idiosyncratic error, which can be understood as a residual component across the panel. Arellano and Bover (1995) subsequently modified the two-stage, differenced estimator, which differed from the previous version by rejecting homoscedasticity. In the following years, however, Blundell and Bond (1998) focused on the error component of the models, focusing in particular on the possible distortion of the results due to systematic errors in the estimation of the studied effects of the two-stage estimation. They constructed a systemic GMM model that allows the inclusion of a much larger number of instrumental variables. The problem of error correction was solved only by Windmeijer (2005), whose technical specification of the robust component of the model revealed not only falsely significant results but also different signs of significant coefficients. A robust error vector has become essential for correctly estimating the two-stage coefficients of the dynamic panel GMM model.

Kripfganz and Swarz (2019) subsequently constructed a modified version of GMM estimators with panel data, including many newly introduced diagnostic tests, including modifications of the Sargan and Hansen tests for use in Windmeijer estimation error correction discussed by Sanderson and Windmeijer (2016), lately suggested even by Hansen and Lee (2021). In the case of many studies, it is not even entirely clear how to test the lag setting of the instrumental variables, which do not enter the basic estimation equation but are related to the error component of the model with a robust error vector. Kripfganz and Swarz (2019) state that only if the homoscedastic residual component of the model is confirmed, the moments can be tested using the Hausman test. However, Andrews and Lu (2001) already present the MMSC test (model and moment selection criteria), which makes it possible to compare models precisely in terms of their setting of the moments of the variables of the regression equation, including the moments of the instrumental variables.

The system GMM model with a dynamic panel including intra-period data from part of the missing data is generally described by the following Equation (3):

$$y_{it} = \sum_{j=1}^{p} \alpha_j y_{i,t-j} + x_{it}\beta_1 + v_i + \epsilon_{it} \qquad i = 1,\ldots,N \qquad t = 1,\ldots,T_i \tag{3}$$

where: α_j – the total number of p parameters for estimating the explanatory variable ROE of i firms lagged by one year ($t - 1$); x_{it} means $1 \times k_1$ vector of the predetermined variable ROA; β_1 is $k_1 \times 1$ vector of parameters exploring the leverage to be estimated; v_i – panel effects that can be correlated with regressors; ε_{it} – the residual, i.e., the panel of idiosyncratic estimation errors, having a variance σ_ε^2.

In our case of a two-stage GMM model and the examined period 2012–2021, $T_i = 8$, the predetermined variables are the macroeconomic indicators of the share of savings in GDP and the share of consumption in GDP in selected countries, and the endogenous microeconomic variable is the share of retained earnings among the regressors in the total assets of the group variable in the cross-section of the panel, firms i. The assumption of the functionality of the model is non-correlation v_i and ε_{it}. In general, ROA and ROE are related through the DuPont analysis, with ROA serving as a component that influences ROE along with the financial leverage multiplier. A company that efficiently manages its assets and capital structure can achieve higher ROE and provide better returns to its shareholders (Chang et al., 2014; Soliman, 2008).

According to the ORBIS database, there were a total of 15,974 medium-sized companies operating in the Human Health Activities sector from 2012–2021. Of these, 6,954 companies were based in the CEE countries, while the remaining 9,020 companies operated in Western Europe. In particular, financial data from the balance sheet (i.e., total assets, equity), as well as the profit and loss statement (EAT, EBIT), within NACE 86: Human Health Activities, subcategory 862: The Medical and Dental Practice Activities Sector, which can also be divided into three categories, of another subcategory 8623: Dental Practice Activities. From the descriptive statistics in Tab. 1, two important pieces of information are drawn. Whereas profitability has decreased due to the COVID-19 pandemic among those dentistry companies with high ownership

concentration measured through the independence indicator reported by Bureau van Dijk, on the contrary, it has increased among those companies with lower ownership concentration. This does not mean that the pandemic positively affected earnings. However, losses and dividends could have decreased equity and total assets according to Equations (1–2) especially among companies with dispersed ownership. Of course, further analysis of the leverage effect of the DuPont framework using the GMM estimation is needed to prove precisely in which countries the leverage increased, on the other hand. The interquartile range demonstrates the variability of nonnormally distributed data (instead of the standard deviation while the data are normally distributed). Apparently, neither the comparison between ROE and ROA, nor their change due to the pandemic can give us similar results. The variability of ROE is at a higher level. Albeit, higher changes caused by the pandemic may be observed among dental companies with a low ownership concentration. According to the significant results, data have been obtained only for nine European countries: Belgium, Denmark, Finland, France, Great Britain, Italy, Norway, Portugal, and Spain. Due to the insignificant results or not reporting the information about their ownership structure, the total number of investigated companies is 1,128.

Technically, the STATA *xtdpdgmm* command developed by Kripfganz (2019) has been deployed to get the two-step system GMM estimates in Tab. 2. In particular, it is the Blundell and Bond (1998) technique with the robust bias-corrected variance-covariance matrix for standard errors, recommended by Windmeijer (2005). Surely, the Arellano-Bond test for zero autocorrelation in first-differenced errors to test zero hypothesis that conditions in the model are valid. Furthermore, according to Windmeijer (2018), the problem of underidentification has been tested by Cragg-Donald's robust comparative usability evaluation (Lagrange Multiplier version) and Kleibergen-Paap's robust limited information maximum likelihood (LM version). However, the problem of overidentification has been verified by the Sargan-Hansen tests. Only the results highlighted in bold are comparable. Dynamic panel data modelling is inefficient in cases with insignificant lagged L.ROE. Except for Portuguese companies with a low ownership structure, the COVID-19 pandemic has affected the technical diagnostics of GMM models in a good way, especially in the case of companies with a high ownership structure. Both cases of dentistry companies in Norway have been just false-significant due to the problem with the underidentification of models. All these cases are highlighted in grey in Tab. 2 within the next section.

3. Research results

Compared to the relevant reviewed literature, several differences should be highlighted before the discussion. Even though Soliman (2008) decomposes return-on-net-operating-assets (RNOA) using DuPont analysis, it has been different in this particular case. Specifically, cash and cash equivalents should have been included in assets, since companies earned at least

Tab. 1: Descriptive statistics

	Ex ante period 2012–2019		Pandemic period 2020–2021	
	HIGH	LOW	HIGH	LOW
Median				
ROE	31.30	30.96	29.73	33.41
ROA	21.22	20.96	19.52	22.56
Interquartile range				
ROE	28.82	26.91	30.70	30.31
ROA	17.56	15.75	17.21	19.05
Frequency	7,160	1,864	1,790	466

Source: own

some financial revenues during the COVID-19 pandemic. Liquidity and working capital would have received a considerable degree of attention concerning the pandemic in future research. Nevertheless, some recent studies used DuPont analysis within health economics research (Chang et al., 2014; Turner et al., 2015), investigating a specific industry, such as the dental industry, so-called dentistry, is much more efficient than investigating hospitals neither having the portfolio of only health business activities, nor focusing on a particular business related to one specific health issue. However, the results of GMM estimates suggest that DuPont analysis can identify not only financially healthier companies but even reveal a potential investment opportunity comparing dentistry among different countries (Doorasamy, 2016; Fairfield et al., 2009; Nissim & Penman, 2001).

Furthermore, a sizable public dental service with salaried employees and equipment that is funded by general or local taxes is a hallmark of the Beveridge model, sometimes referred to as the National Health Service (NHS) system. When it comes to reducing the DMFT index (decayed, missing, and filled teeth), the Nordic

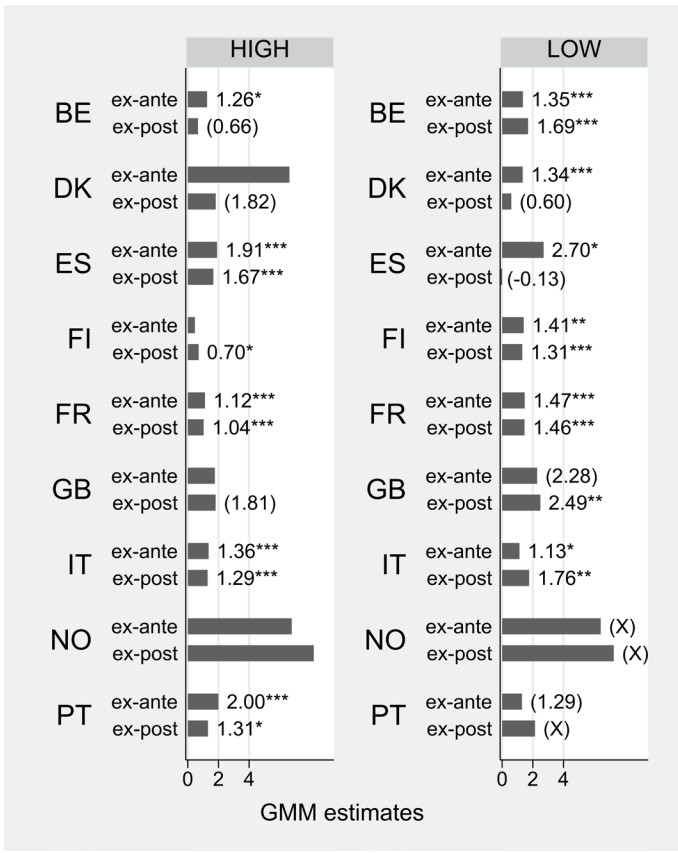

Fig. 1: Estimated DuPont financial leverage using GMM models

Note: ***$p < 0.001$; **$p < 0.01$, *$p < 0.05$; (insignificant), missing non-robust, or (X) false significant results.

Source: own

nations and the UK have outperformed the Beveridge region in the field of stomatology (Pinilla & González, 2009). Several nations, including the UK, Denmark, Finland, Italy, Norway, Portugal, and Spain, have adopted this concept within the results. The Compulsory Universal Health Insurance System, or the Bismarck model, on the other hand, bases healthcare financing on mandatory salary payments. It is claimed that the economic downturn, political unpredictability, widening social divides, and rising unemployment rates make the implementation of the Bismarckian insurance program in many countries seem unfeasible. Countries in the FSE (former socialist economies) region are linked to this model. Although, Belgium and France have adopted this system for dentistry as well. Nevertheless, the material that is currently available omits important information regarding the precise application of the Bismarck model to stomatology, further also according to the ownership structure of dentistry companies (Deppe & Oreskovic, 1996; Welch, 2003).

The financial leverage multiplier magnifies the impact of ROA on ROE in Tab. 2 with the system GMM estimates. If a company takes on more debt relative to equity (higher financial leverage), a smaller ROA can still result in a higher ROE due to the increased financial leverage (Chang et al., 2014; Turner et al., 2015), i.e., those companies with a LOW concentration of ownership structure. The comparison is made from several points of view. First, the estimated leverage effect can be compared from the ownership concentration point of view. Except for the pre-pandemic period in Italy, the leverage effect of DuPont analysis measured by the equity multiplier tends to be slightly lower among dentistry companies with HIGH ownership concentration in Fig. 1. However, it tends to be lower during the pandemic period. It means that future profits will be many times more than the cost of borrowing amongst dentistry firms with more than one owner, which supports the idea of mergers amongst dentistry companies. This result does make sense if the LOW dispersed ownership allows the use of debt financing rather than equity. On the other hand, this result is supported by Caselli and Negri (2021), who argued that the owner uses equity rather than debt, i.e., the case of a HIGH concentrated ownership structure. Hence, more owners will either decrease the costs of capital, as well as allow the usage of a higher level of debt capital. Second, the impact of the COVID-19 pandemic can be seen in selected cases among both groups of dentistry companies. The pandemic and the accompanying economic downturn have an impact on dentistry, just like they do on other healthcare sectors (Patel, 2020), and even from the DuPont financial leverage point of view, this impact is evident in Fig. 1. On the one hand, decreasing (or increasing) equity caused by the potential share of retained earnings (or reinvestments) during the pandemic will increase (or decrease) the profitability of a firm. On the other hand, any change will affect ROE more than ROA. However, we can see a negative change in the effect of leverage in France (1.12 ex-ante, 1.04 ex-post), Portugal (from 2.00 to 1.31), and Spain (1.91 and 1.67) among companies with HIGH ownership concentration. This result supports the idea of reinvestments during the pandemic developed in the previous paragraph. Quite the opposite is the massive positive change of leverage in Belgium (1.35 ex-ante, 1.69 ex-post) and Italy (1.13 and 1.76) among companies with LOW ownership concentration, caused by negative changes in equity. However, this result could have been caused by mergers in dentistry, not only by losses related to the pandemic.

In the Bismarck model (i.e., Belgium and France), dental care is dependent on social insurance contributions, where both employers and employees contribute to a health insurance fund. Hence, the profitability of dental care can be influenced by patient's ability to access and afford dental services based on their insurance coverage. Dentists can negotiate reimbursement rates with insurance companies, which can affect their income. On the other hand, in the Beveridge model (i.e., Italy, Portugal, and Spain), dentistry is primarily funded by the government through taxation, which means that dental care may be more likely to be included as part of the publicly funded healthcare system. The profitability of dentists can be influenced by government-set reimbursement rates, which may be lower than what they could charge in a purely private system. However, a consistent patient base and reduced administrative burden could offset this. Most importantly, the COVID-19 pandemic affected different economies at very different levels, while the Italian economy belongs to those most affected in the world. Perhaps that would

be a reason why we see differences even between the opposite impact of the leverage between Italy, Portugal, and Spain, or even between Belgium and France in the previous paragraph. Furthermore, the ownership structure has affected especially the Italian case, where we can see an increasing leverage effect among companies with LOW concentration and dispersed ownership. A decreasing effect may be even more obvious for companies with major owners in Portugal and Spain.

An interesting finding is that in terms of the comparison of financial leverage in Belgium and Italy, the leverage is close in both economies, even though different healthcare systems are used there. This is probably because Italy started to support its healthcare more during and after the pandemic, as well as Belgium (in different health systems). They focused on improving the continuity and coordination of healthcare. Attention is paid to many aspects of the Italian national health system by transforming primary care into community care (Mauro & Giancotti, 2023). Concerning that, a reform of the health sector and healthcare support was introduced in Italy. This applies not only to primary care but also to other areas of health care provided, including dental care. A reform was also introduced in Belgium, which was already prepared before the pandemic but was not implemented until 2020 (Heede et al., 2023). There is, therefore, a clear similarity in the support of health care in these two countries and, therefore, also in the approaches

Tab. 2: DuPont leverage effect using ROE as the dependent variable

HIGH ownership concentration									
Pre-pandemic period									
	BE	**DK**	**ES**	**FI**	**FR**	**GB**	**IT**	**NO**	**PT**
L.ROE	0.4266^{c}	2.6898	−0.0230^{c}	−0.2697	0.0687^{c}	−0.0546	0.0159^{c}	0.3492	0.0193^{c}
ROA	**1.2575^{c}**	6.6252	**1.9075^{a}**	0.4627	**1.1202^{a}**	1.7631	**1.3566^{a}**	6.7772	**1.9972^{a}**
COVID-19 pandemic included									
	BE	**DK**	**ES**	**FI**	**FR**	**GB**	**IT**	**NO**	**PT**
L.ROE	0.8526^{a}	0.4776^{c}	−0.0102^{c}	−0.2494^{c}	0.1169^{c}	−0.0145	0.0582^{c}	0.3026	−0.0886^{c}
ROA	0.6623	1.8195	**1.6682^{a}**	**0.7049^{c}**	**1.0361^{a}**	1.8107	**1.2923^{a}**	8.2141	**1.3135^{c}**
LOW ownership concentration									
Pre-pandemic period									
	BE	**DK**	**ES**	**FI**	**FR**	**GB**	**IT**	**NO**	**PT**
L.ROE	−0.3059^{a}	0.3855^{b}	−0.0418^{c}	−0.0504^{c}	−0.0810^{c}	0.5108^{a}	0.0862^{c}	0.5205^{a}	−0.2173^{a}
ROA	**1.3550^{a}**	**1.3394^{a}**	**2.7039^{c}**	**1.4064^{b}**	**1.4703^{a}**	2.2816	**1.1297^{c}**	6.4255^{c}	1.2918
COVID-19 pandemic included									
	BE	**DK**	**ES**	**FI**	**FR**	**GB**	**IT**	**NO**	**PT**
L.ROE	−0.7109^{c}	0.6777^{b}	0.1792^{c}	−0.0384^{b}	−0.1331^{c}	0.4507^{a}	0.0166^{c}	0.0176^{c}	−0.0773
ROA	**1.6920^{a}**	0.5959	−0.1309	**1.3098^{a}**	**1.4566^{a}**	**2.4884^{b}**	**1.7611^{b}**	7.2767^{b}	2.1420^{a}

Note: Symbols ^{a} for $p < 0.001$, ^{b} for $p < 0.01$, and ^{c} for $p < 0.05$. Valid leverage effects highlighted in bold, otherwise grey cells. The two-step system GMM estimation technique by Blundell and Bond (1998) with the robust bias-corrected variance-covariance matrix for standard errors, recommended by Windmeijer (2005), and the STATA *xtdpdgmm* command developed by Kripfganz (2019). Amongst diagnostic tests, the Arellano-Bond test for zero autocorrelation in first-differenced errors has been estimated to test whether the moment conditions in the model are valid, further, according to Windmeijer (2018), the underidentification tested by Cragg-Donald robust CUE-based (LM version) and Kleibergen-Paap robust LIML-based (LM version), and finally, overidentification tested by the Sargan-Hansen test.

Source: own

to health care financing. On the other hand, in France, where the effect of financial leverage is the opposite, a major reform has been launched since 2020, but this reform is being introduced gradually and, for the time being, does not affect the area of dental care provision. However, in the area of dental care, significantly high household expenses are defined compared to other areas of healthcare (Or et al., 2023).

Conclusions

Focused on the DuPont framework, this article aimed to estimate the effect of leverage and its changes due to the COVID-19 pandemic among dentistry companies in selected European countries having either the Beveridge model (National Health Service System) or the Bismarck model (Compulsory Universal Health Insurance System). To answer those three research questions formulated within the Introduction: i) It is hard to argue that just a different healthcare system is crucial from the point of view of the pandemic impacts. This particular effect is not similar, especially among Italy, Portugal, and Spain, which have the Beveridge system, nor is it the same between Belgium and France, which have the Bismarck system; ii) The GMM technique is apparently not appropriate for the DuPont framework to evaluate these pandemic impacts due to post-estimation techniques such as over- and under-identification of the moments within the models. Hence, different techniques, i.e., heterogeneous difference-in-differences with different cohorts of companies, will be used in future research focusing on this framework regarding the pandemic. However, even though the data for ownership structure data were obtained only for its concentration, more leveraged effects based on DuPont analysis caused by the pandemic were evident either for those dentistry companies with a major owner in Portugal or for those companies with dispersed ownership structure, especially in Belgium and Italy; and iii) Additionally, mergers among dentistry companies are possibly evident among Portuguese dentistry companies that have a high concentration of owners or Belgian and Italian companies that have a low concentration. However, among these particular groups of companies, the use of debt financing is preferred to the use of shareholders' funds.

Although the results of this paper are robust, there are some limitations. Foremost, the leverage effect of the DuPont analysis was not significant for dentistry companies in many countries. Due to this fact, the investigation was carried out only in nine European countries. It is not an argument to reject the DuPont framework to measure the impact of the pandemic in different business industries, though. Another point of view would be solved in future research focusing on differences between NUTS3 units, as dentistry would have been highly dependent on actual COVID-19 cases. A combination of a higher ROA and appropriate financial leverage can lead to a significantly higher ROE. However, it is crucial to note that increased financial leverage also comes with higher financial risk, as the company has to pay interest on its debt (Solomon, 2008). Therefore, finally, further research on ROA and the efficiency of asset management efficiency among European dental companies will be carried out.

Finally, we argue that the differences between different models of healthcare financing within financial performance relations according to the DuPont framework were apparent neither before nor during the period affected by the global pandemic crisis. Such results are further supported by Widström and Eaton (2004). Nevertheless, the impact of a different ownership structure is inevitable.

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The impact of the effective tax rate change on financial assets of commercial banks: The case of Visegrad group countries

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Abstract: *While many tax professionals have discussed corporate taxation in the banking sector and its effectiveness on bank institutions, investment decisions, bank size, asset structure, or bank rentability, there is little evidence of tax efficiency within V-4 Group. The research on banks and tax rates is mainly based on American data. Few papers solved banking stability and corporate taxes within the European countries. This paper examines effective corporate taxation in the banking sector of the V-4 Group and aims to find out how the effective tax rate change affects commercial banks' financial assets. In this study, we examine the relationship between variables using regression analysis in which we assess the impact of ETR on bank financial assets. We examined data in the consolidated financial statements data of commercial banks and tested their impact on the economy. Our findings supported the theory that ETR impacts the banking sector, particularly capital and equity financing. However, the results did not prove the research hypothesis, in which we assumed that an increase in ETR would lead to an increase in financial assets. Based on our results, it leads to an increase in equity assets (7.34%) and a decline in debt assets (16.83%).*

Keywords: *Tax effectiveness, banking sector, tax competitiveness, taxable income.*

JEL Classification: *H20, H21, H25.*

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Introduction

The tax burden of financial transactions is a complicated issue mainly due to discrepancies in financial and non-financial characteristics. The effective tax rate (ETR) is an average rate that expresses a percentage of tax expenditure of the total taxable income. Compared to the statutory tax rate (STR), ETR is a better indicator for investment decisions and foreign investors because it determines the real level of taxation. Each country has its fiscal policy and sets the level of STR individually, so there are some tax disparities between the countries. Therefore, within the V-4 Group, analysing these differences in tax rates is meaningful. Our research aims to understand the differences

between ETR and STR better and tries to provide evidence that investment decisions would be based on an analysis of the effective rate rather than the statutory tax rate.

We identify differences between the V-4 countries related to ETR in commercial banks. We analyse ETR based on regression analysis. According to empirical findings, V-4 countries are remarkably similar in developing debt assets and bank rentability. We selected the research sample based on common characteristics in the financial as well as the economic development of this group. We wanted to contribute to empirical findings on how the change of effective tax rate affects the financial assets of V-4 Group's commercial banks.

Moreover, we aim to support the discussion on tax harmonisation within the Eurozone area. Data were retrieved from the consolidated financial statements of commercial banks and the ECB Statistical Warehouse. The article aims to evaluate how change in ETR affects commercial banks' financial assets. We assume that internal factors correlate more with ETR than external ones.

The first section of the article discusses a literature review in the field of effective taxation. The second section describes methods. In the third section of this contribution, we compare the development of the internal (bank rentability, debt assets, equity assets, net interest income, cost-income ratio) and external factors (economic growth, nominal statutory tax rate, gross fixed capital formation, inflation rate) in the selected countries. In the fourth part, based on the regression model, we analyse ETR in commercial banks in the V-4 Group, and the last part concludes.

1. Theoretical background

Most studies examine corporate tax rates based on non-financial companies' or multinational enterprises' data (Farah et al., 2021; UNCTAD, 2020) or evaluate corporate rates related to tax competitiveness, economic stability, and tax revenues. Zeng and Peng (2020), Sosnowski (2020) and Podviezko et al. (2019) found that lower levels of tax rate affects positively on stability tax competitiveness of the national economy and eliminate the shadow economy.

In the research of financial institutions, recent taxation studies focus on determining factors that influence ETR. These studies are based on American data (Schandlbauer, 2017) or Australian data (Murphy, 2017), but there is a gap in European research. Based on the European data, Delgado et al. (2014) analysed differences between ETR and STR and their change in bank size, asset structure and rentability. They proved that different tax rate levels provide to countries' tax competitiveness. Overesch and Wolff (2019) investigated ETR in European banks and non-financial firms and found a negative correlation between ETR and bank size. Moreover, international commercial banks react better to ETR changes than small domestic banks. Masiukiewicz and Dec (2012) dealt with ETR in the financial crisis and analysed its impact on bank taxes in the EU.

The evidence about the impact of ETR on banking performance provided studies by Kohlscheen et al. (2018), Schandlbauer (2017), and Gallemore et al. (2017), which confirmed that if ETR increases, better-capitalised banks will reduce capital financing and focus on debt financing. From earlier studies, it is known that the higher ETR, the higher operational costs and the lower cash flows and financial performance of commercial banks. Fiordelisi et al. (2011) pointed out the opposite, meaning a reduction of ETR will lead to lowering costs and inefficient risk management in non-financial firms. However, no unambiguous evidence exists that higher ETR directly affects financial assets. The reason can be that if ETR changes, banks may change the structure of financial assets and use ETR to manage regulatory capital. Gallemore et al. (2017) found that, on average, financial institutions, compared to non-financial firms, have a low correlation of ETR with taxable income, liquidity, debt, and risk. Andries et al. (2017) and Dietrich and Wanzenried (2011) confirmed an inverse correlation between ETR and the financial stability of commercial banks (measured as ROA). Burger and Moormann (2008), Slemrod (2004) and Hanlon and Heitzman (2010) provided evidence that ETR affects non-financial activities. Shevlin et al. (2017), Richardson and Lanis (2007), Nicodème (2002), and Gilson and Schizer (2003) examined ETR and risk speculative strategies, and they concluded that change in ETR will lead to capital outflows to countries with low taxation. Other studies (Baltagi et al., 2006; Chaudhry et al., 2015; Claessens & Laeven, 2005; Hau, 2006) are focused on analysing the effects of the different tax systems on economic activity and economic stability. However, from these

findings, it is unclear to what extent fiscal policy regulation is sufficient and when it is necessary to coordinate economic stability with the central bank. Generally, there is an agreement that bank regulation, equity assets and net interest income have statistically insignificant influence on tax rates and economic growth and that ETR positively influences economic development (Gaston & Song, 2014).

Tab. 1 concludes research areas focused on analysing effective rates in the banking sector.

We assume that commercial banks' taxation statistically significantly influences banks' internal environment. In the regression model, we evaluate ETR as an independent variable and ROA, debt assets, equity assets, net interest income, cost-income ratio, GDP growth, STR, fixed investments and inflation rate as dependent variables. In literature and practice (Tab. 2), most studies use econometric models for the analysis of effective rates (Gambacorta & Murcia, 2020; Langedijk et al., 2014; Sundaresan & Wang, 2014). Difference-in-difference analysis (Schandlbauer, 2017), or dynamic general equilibrium models (Boscá et al., 2019).

Our current paper contributes to knowledge of how the change of effective tax rate affects the financial assets of commercial banks of V-4 Group. We were motivated to write this study to draw attention to effective tax rates in the banking sector. As there is a lack of research with similar specifications, the prime aim was to support the discussion about tax harmonisation within the eurozone area.

2. Research methodology

Theoretical findings by Feeny et al. (2005), Wilkinson et al. (2001) and Stavarek (2005) indicate that equity assets are positively correlated with the tax rate. Fewer studies, such as Delgado et al. (2014), provided evidence of a negative correlation between ETR and debt assets. The sample was realised based

Tab. 1: Empirical research focused on ETR

Authors	Research area	Findings
Nicodème (2002) **Delgado et al. (2014)** **Overesch and Wolff (2019)** **Masiukiewicz and Dec (2012)**	Analysis of ETR and statutory tax rate in the EU states	Different level of tax rates within the EU states harms competitiveness; confirmed a negative correlation between ETR and bank size
Schandlbauer (2017) **Kohlscheen et al. (2018)** **Gallemore et al. (2017)** **Andries et al. (2017)** **Dietrich and Wanzenried (2011)**	Analysis of ETR, banking activities and bank regulation	A bank price policy of higher interest margin would lead to a negative correlation between ETR and profitability
Hau (2006) **Baltagi et al. (2006)** **Chaudhry et al. (2015)**	Analysis of ETR and fiscal policy	Economic growth has an impact on the banking system and bank competitiveness
Claessens and Laeven (2005) **Gaston and Song (2014)**	Analysis of ETR and economic activities	Confirmed negligible statistical significance between tax rate and economic growth
Burger and Moormann (2008) **Slemrod (2004)** **Hanlon and Heitzman (2010)** **Fiordelisi et al. (2011)**	Analysis of ETR and managing business activity	Tax rates can be used as an instrument for managing the stability of a company
Richardson and Lanis (2007) **Nicodème (2002)** **Gilson and Schizer (2003)** **Shevlin et al. (2017)**	Analysis of ETR and tax optimisation	Differences in effective and statutory tax rates can be used for speculative strategies such as tax optimisation or capital transfers

Source: own

Tab. 2: Methodology used for analysing ETR

Authors	Methodology	Research area
Langedijk et al. (2014)	Regression model based on panel data	Analysis of debt costs in banking structure and its influence on tax rates and gross public debt in economic crisis
Schandlbauer (2017)	Difference-in-difference analysis	Comparison of a change of statutory tax rate on capital structure in American banks and financial institutions
Gambacorta and Murcia (2020) **Sundaresan and Wang (2014)**	Econometric model	Examination of a change of tax rates on the fair value of liabilities in the balance sheet of commercial banks
Boscá et al. (2019) **Alves (2018)**	DSGE model	Examination of taxes on the banking sector in small open economies

Source: own

on the V-4 Group, i.e., the Czech Republic, Hungary, Poland, and Slovakia, because these countries are economically and historically close. Therefore, we want to determine whether they are harmonised with taxation within the banking sector. We assume that ETR in the V-4 Group has a statistically significant influence on analysed variables, as expressed by the following null hypothesis:

H0: An increase in ETR has a significant positive effect on the financial assets of commercial banks in the V-4 Group.

We analysed 2007–2019 to compare ETR during economic expansion and crisis. De Jonghe (2009), Kohlscheen et al. (2018), and Racicot and Théoret (2018) also analysed how ETR affects bank stability and how bank regulation impacted equity assets after the financial and debt crisis in 2008. They confirmed that ETR has a statistically significant impact on economic growth and bank stability.

According to Stavarek (2005), the common attributes of V-4 are privatisation of commercial banks, harmonisation of bank legislation with EU directives and improvement of bank regulation after the entrance into the EU. A positive benefit for all these countries was the inflow of foreign investments because they improved financial performance and made bank and insurance activities more efficient. Differences among these countries can be found in developing the bank system and providing loans to economic entities.

2.1 The characteristics of variables in the model

As dependent variables in the model, we chose bank rentability on assets (ROA), debt and equity assets, net interest income (NII), and cost-income ratio (CIR). Also, we added some other variables, such as GDP growth, STR, inflation rate and gross fixed capital formation (GFCF). We calculated ROA and ETR based on data from consolidated financial statements published by the national central banks of the individual countries. Since Czechia, Poland and Hungary values were expressed in the national currency, we converted them by ECB reference rates applied at the end of a year. We expressed ROA as a ratio of net profit to financial assets as follows:

$$ROA = \frac{Net\ profit\ of\ commercial\ banks\ at\ 31.12.}{Total\ financial\ assets} \times 100 \quad (1)$$

Debt and equity assets (million EUR) were converted by logarithm because we wanted to eliminate extreme values. These values were retrieved from consolidated financial statements for 2007–2017 as balance sheet items Debt securities, Financial instruments for sale, Financial instruments at fair value through profit or loss, and Financial instruments held to maturity. In 2018, the methodology for financial instrument presentation was changed. Since that year, debt and equity assets have been presented in more detail as items Financial assets at amortised costs, Financial assets at fair value through profit or

loss, and Financial assets at fair value through other comprehensive income.

We calculated ETR as a ratio of tax expenditure to taxable income each year:

$$Effective\ tax\ rate\ (ETR) = \frac{Tax\ expense}{Taxable\ income} \times 100 \quad (2)$$

Values for variables GDP growth (as a percentage change of GDP), NII (as a ratio of interest income to total assets), and CIR (as a ratio of operational costs to interest income) were retrieved from the ECB Statistical Warehouse. Data for the inflation rate (as an annual change in the price level) and GFCF were retrieved from Eurostat. We chose CIR as an additional control variable because, according to Burger and Moormann (2008), CIR represents a key indicator of bank performance.

As was mentioned above, we analysed the change in ETR and assumed that when there are changes in the economy (such as crisis, legislation, accounting standards), commercial banks will react more efficiently by changing internal processes than they can influence external factors. Gallemore et al. (2017), Brunnermeier et al. (2020), and Purina (2007) also confirmed this hypothesis. The regression model is formulated as follows:

$$\begin{aligned} ETR &= \beta_0 + \beta_i . internal\ variables_{it} + \\ &+ \beta_j . external\ variables_{jt} + \varepsilon \\ ETR &= \beta_0 + \beta_1 . ROA + \beta_2 . \log(Debt\ assets) + \\ &+ \beta_3 . \log(Equity\ assets) + \beta_4 . NII + \\ &+ \beta_5 . CIR + \beta_6 . GDP\ growth + \beta_7 . STR + \\ &+ \beta_8 . Inflation\ rate + \beta_9 . GFCF + \varepsilon \end{aligned} \quad (3)$$

Our study indicated a standardised root mean square of 0.1021, multiple *R* of 0.63, and standard error of 0.31. Thus, it seems to be a good fit model to find out the effect of ETR (Fig. 1; Tab. 2).

3. Results and discussion

Before we ran the regression analysis, we compared the development of some financial variables in the individual countries. We assumed that ETR and economic variables would have similar development within the V-4 Group (Glova et al., 2020). Fig. 2 shows the development of ETR in all countries. We can see a similar development in Czechia, Slovakia, and Poland, where ETR ranged between 15% and 25%. The lowest rate was in Czechia (above 15% on average). In Slovakia, ETR was significantly influenced by the financial crisis 2009 when it dropped from 26.56% (2009) to 16.21% (2012). Then, in 2013, it rose again (24.56%), stabilising at around 24%. Similarly, in Poland, ETR was stable until 2012. However, after 2013, ETR increased remarkably (from 18.80% to 27.78% in 2019).

The different situation was in Hungary. In 2007–2009 was, ETR development relatively the same as in the other countries (around 15%). The breakpoint for its development was the government's reaction to the financial crisis. The Hungarian government introduced new taxes for the banking sector and other economic industries, e.g., telecommunication. That led to a reduction of ETR, devaluation of the Hungarian national currency to euro

Tab. 3: Model assumption

Variable	Estimation	*p*-value
ROA	Positive	0.3621
Debt assets	Negative	0.2457
Equity assets	Negative	0.4772
GDP	Negative	0.1493
NII	Positive	0.2164
CIR	Negative	0.0400
NTR	Positive	0.1218
Inflation rate	Negative	0.2305
FDI	Negative	0.6943

Source: own

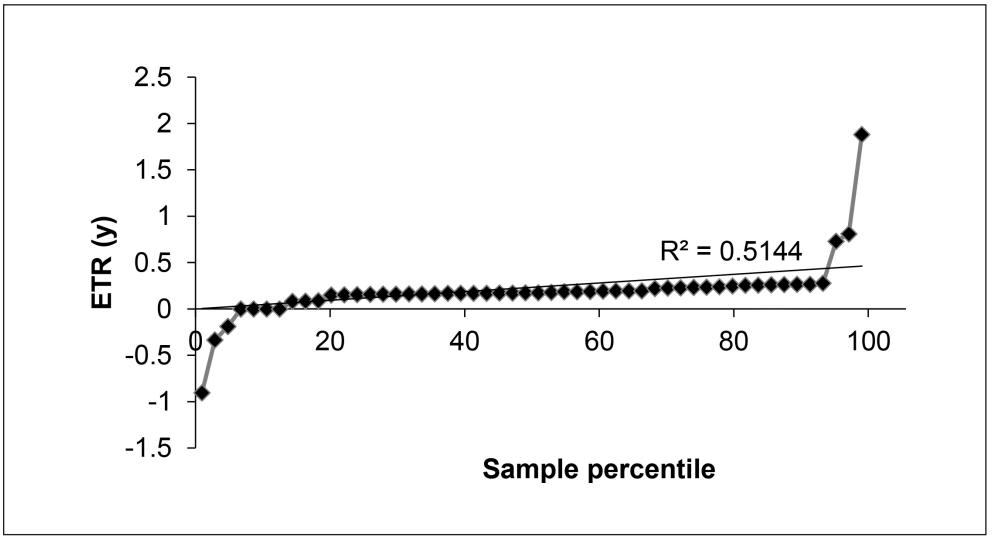

Fig. 1: **Normal probability testing**

Source: own

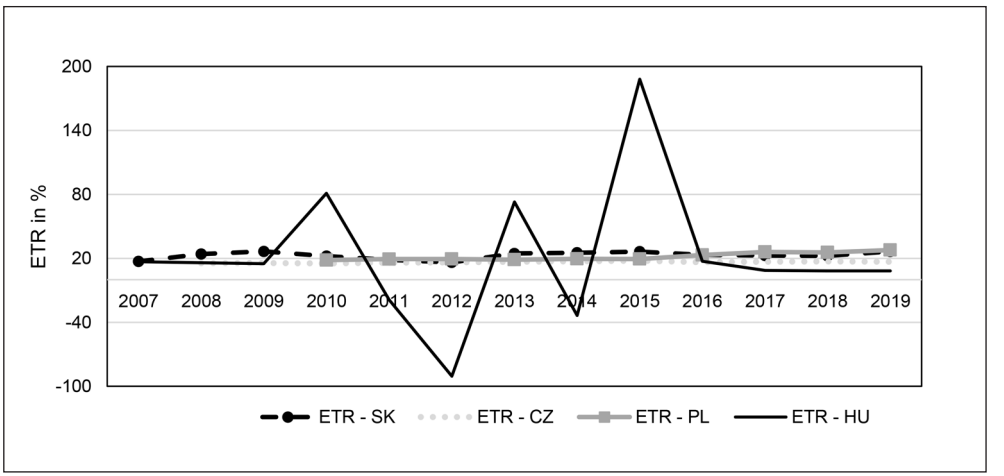

Fig. 2: **The development of effective tax rate in V-4 (%, 2007–2019)**

Source: own (based on ECB (2020))

by more than 30%, the outflow of foreign investors and changes in providing loans to households. Consequently, commercial banks started to have problems with higher operational costs, level of regulatory capital, and financial performance (Valentinyi, 2012). Debt liabilities also influenced the reduction in ETR in the balance sheets of commercial banks, which rose from 2009 and then, in 2011, dropped again to the original level

(Fig. 3). The negative correlation between ETR and total liabilities was confirmed by Purina (2007) and Barjaktarović et al. (2013). In 2015, ETR significantly increased again, assumably due to the level of regulatory capital, which increased in 2012–2016 by almost 90% (from 2,160.03 million EUR to 3,869.647 million EUR; Fig. 4). The Hungarian ETR reached the highest level in 2015 (up to 188%), while in the next period 2016–2017 fell by more than 70%. Similarly, high values of ETR were found by Purina (2007) in the Russian commercial bank VTB (96.04% in 2014, 56.10% in 2015). Deutsch and Pintér (2018) confirmed a small positive impact of bank capital on the level of taxable income and a negative impact on rentability on assets. Since 2016, the Hungarian ETR has reduced by 17%, and in 2017–2019 reached the lowest level within the V-4 Group (8%). Compared to the development of macroeconomic indicators in Hungary, ETR could be influenced by the reduction in STR from 19% to a flat tax of 9% in 2017, the lowest tax rate within all EU states (Tab. 4). This reduction led to an improvement in GDP by almost 20% and a reduction of ETR in banking at 8%. Some indicators were not affected by changes in ETR, such as total tax revenues, government expenditures, gross debt, a deficit of public finances, and inflation rate, which indicated a negative correlation.

3.1 Rentability of assets

The data for the variable ROA showed similar development as ETR (Fig. 5). The lowest value within V-4 reached Slovakia (on average 0.86%), then Poland (1.03%) and Czechia (1.20%). In Slovakia, bank rentability was strongly influenced by domestic economic development and external factors, particularly in 2009 when GDP growth decreased, and the euro replaced the national currency. Consequently, bank rentability was reduced by more than 50%. Many banks started having problems with higher credit loss costs and lower interest income. In 2010, a slight improvement was supported by the improved financial position of Slovak banks, economic growth, and preventive fiscal and monetary policy measures. In 2011–2012, ROA dropped again due to the worse ability of firms and households to repay loans. Then trend in the Slovak banking sector recorded stable development with sufficient liquidity level and minimal dependency of domestic banks on their foreign parental institutions. A more noticeable decrease in ROA appeared again

Tab. 4: ETR and nominal tax rate in non-financial firms and commercial banks in V-4 (%, 2007–2019)

	Hungary (HU)			Poland (PL)			Czech Republic (CZ)			Slovakia (SK)		
	STR	ETR nonfin	ETR banks	STR	ETR nonfin	ETR banks	STR	ETR nonfin	ETR banks	STR	ETR nonfin	ETR banks
2007	20	20	17	19	17	–	24	21	–	19	21	17
2008	20	20	16	19	17	–	21	18	16	19	20	24
2009	20	20	15	19	18	–	20	18	16	19	19	27
2010	19	19	81	19	18	18	19	17	15	19	18	22
2011	19	19	19	19	18	19	19	17	16	19	18	19
2012	19	19	91	19	18	19	19	17	16	19	16	16
2013	19	19	73	19	18	19	19	17	17	23	16	25
2014	19	19	−34	19	18	20	19	17	17	22	16	25
2015	19	19	188	19	18	19	19	17	18	22	16	26
2016	19	19	17	19	18	23	19	17	16	22	16	23
2017	9	11	9	19	18	26	19	17	17	21	17	23
2018	9	11	8	19	18	26	19	17	17	21	17	22
2019	9	11	8	19	18	28	19	17	17	21	17	27

Source: own (based on ECB (2020))

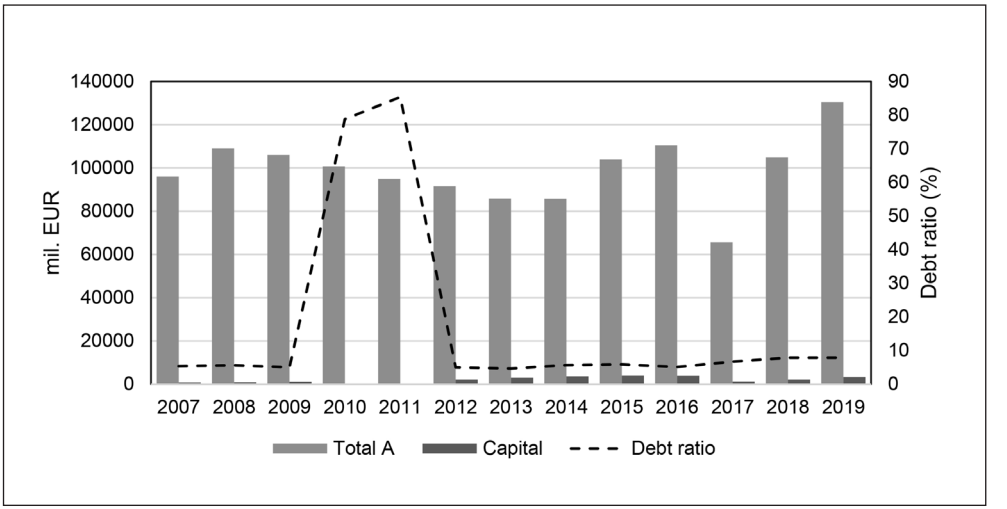

Fig. 3: **The development of total assets, capital (million EUR) and debt ratio in Hungary (%, 2007–2019)**

Source: own (based on ECB (2020))

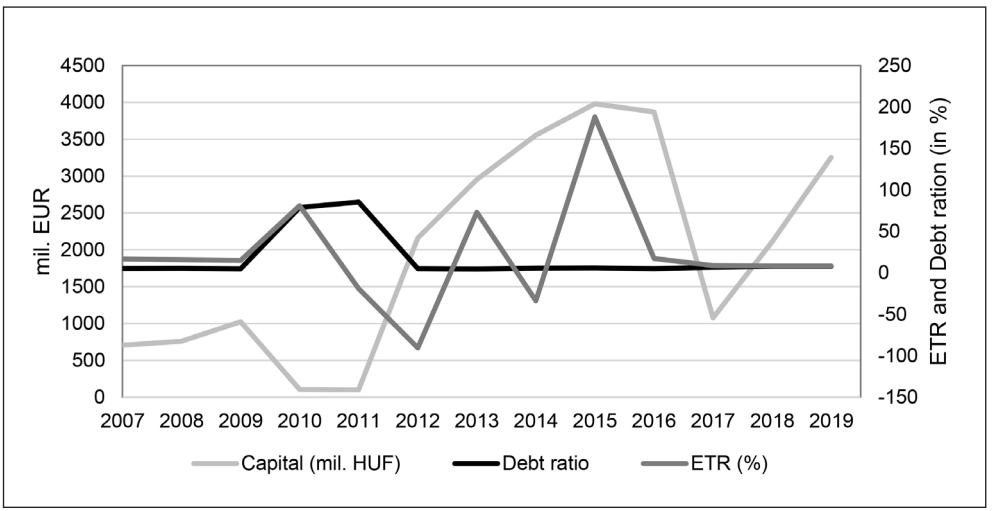

Fig. 4: **The development of capital (million EUR), debt ratio and ETR in Hungary (%, 2007–2019)**

Source: own (based on ECB (2020))

in 2019 because of the long-term decrease in interest margin. However, even if ROA is currently the lowest, this environment is not advantageous for foreign investments.

Despite the economic slowdown, Czech commercial banks after 2008 kept a stable position and the highest rentability of all V-4 states. The main negative factor was weakened

GDP growth, lowering interest rates on consumer loans and reducing loan repayments from private households.

Similarly, like other European states, the financial crisis jeopardised the development of Polish macroeconomic indicators. In 2008–2009, the main factors of lower rentability of Polish banks were worse quality of bank portfolio, more limited loan provision and economic slowdown. The banking sector suffered a significant reduction in income and higher costs for credit losses. Periods 2010–2012 were associated with activating economic growth and higher bank rentability. The negative factors jeopardising financial stability remained the instability of public finance, the eurozone debt crisis, and a high gross debt level. The period 2013–2014 was relatively stable for bank rentability; net interest margin increased, and the quality of financial assets improved. In 2015, financial institutions reported losses due to lowering interest margins, even though a sufficient level of regulatory capital compensated for these losses. Recently, Polish banks have continued lowering rentability because of low non-interest income, higher contribution to guarantee funds and negative interest rate spread.

In Hungary, bank rentability was influenced by the above-mentioned political factors. In 2007–2010, ROA was at the same level as in other V-4 states (on average 0.89%), then bank rentability markedly reduced (−2.03%) and rose again at 1.47%.

3.2 Financial assets

An interesting development showed financial assets in balance sheets (Figs. 6–7). While the development of debt assets in individual countries was stable, external factors influenced equity assets. The highest level of debt assets in the analysed period was recorded in Czechia and the lowest in Slovakia. For this period, Czech commercial banks had no difficulties with debt assets or with liquidity strain because the Czech national bank realised a write-off of toxic assets of more significant financial entities. In Poland in 2014, debt assets noticeably increased (almost 21%), and their volume is still rising, meaning the highest value in all countries. This increase was influenced by credit risk and changes in the structure of balance sheet items to cover debt costs. In the case of equity assets in Slovakia, they dropped by more than 60% for a period. This dramatic decline was due to the GDP slowdown, the debt crisis in the eurozone, the low inflation rate, and worse conditions in the labour

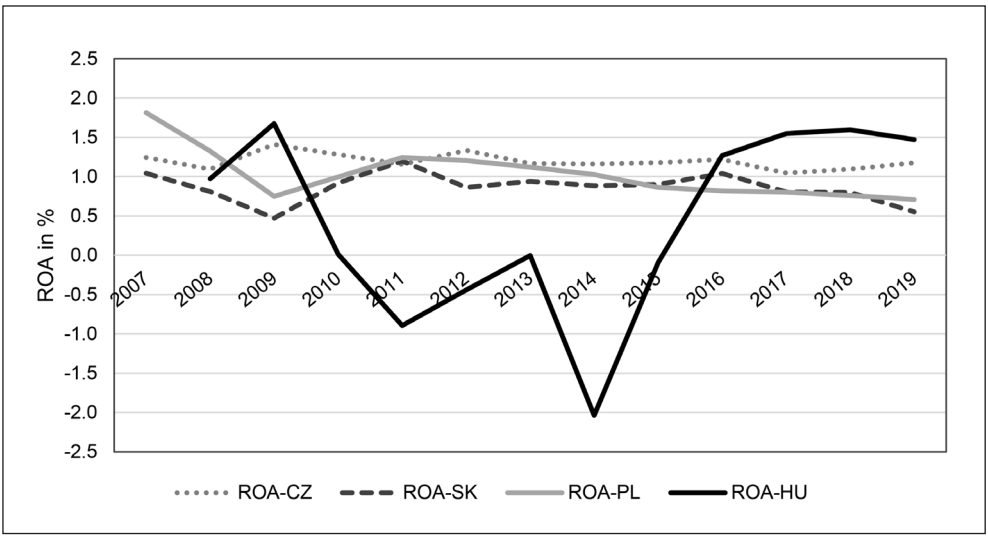

Fig. 5: **The development of ROA of commercial banks in V-4 (%, 2007–2019)**

Source: own (based on ECB (2020))

market in the domestic economy. In Czechia, Poland and Hungary, equity assets show an upward trend. The important risk factors in Czechia were a decline in export and industrial production, enterprises' insolvency and interest rate margin growth. Foreign investors still demanded crucial Czech financial assets from a domestic financial stability perspective and uncertain economic conditions. Poland adopted stimulating monetary policy measures 2009 to support capital requirements, increase capital adequacy and stabilise the banking sector. External factors influencing the development of financial assets were the decision of the ECB to buy government bonds and

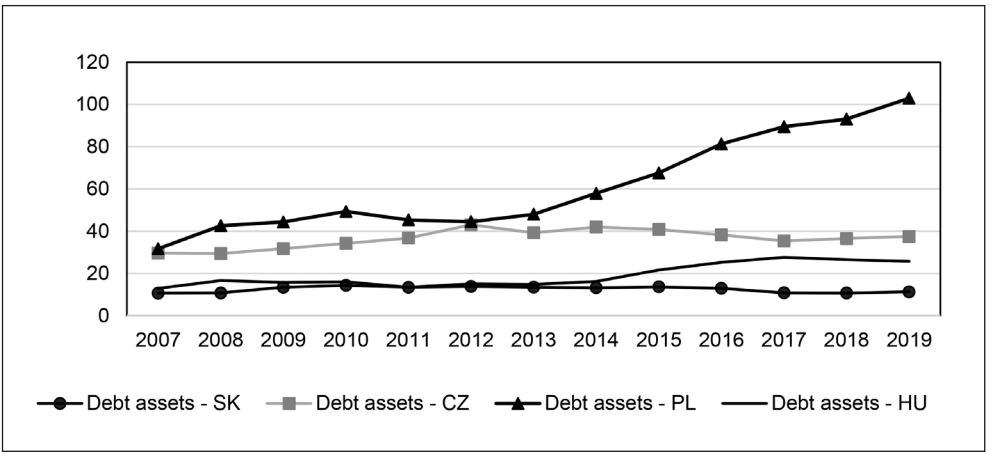

Fig. 6: **The development of debt assets in V-4 (billion EUR, 2007–2019)**

Source: own (based on ECB (2020))

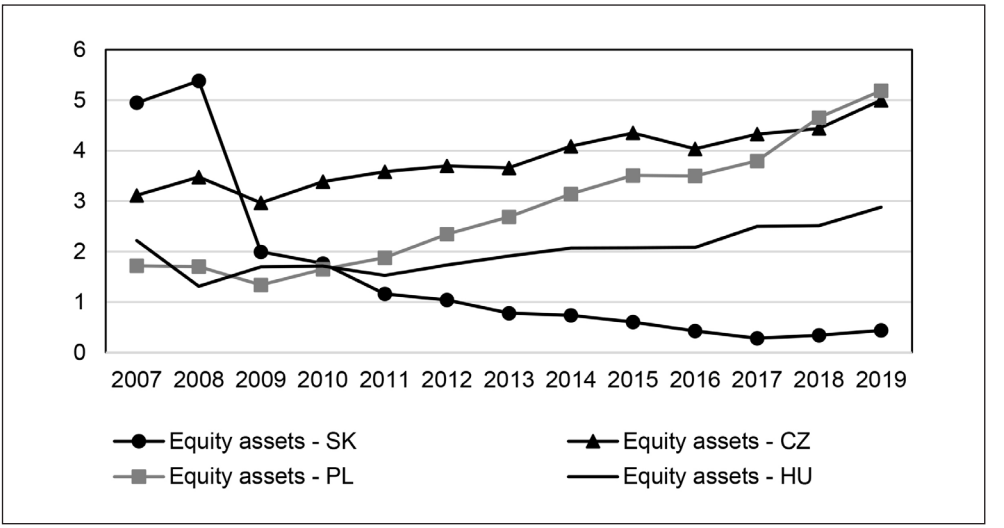

Fig. 7: **The development of equity assets in V-4 (billion EUR, 2007–2019)**

Source: own (based on ECB (2020))

the new accounting methodology for financial instruments, IFRS 9, adopted by commercial banks in 2018.

3.3 Discussion

We found a statistically insignificant relationship after evaluating all correlations between ETR and selected variables (α = 0.05). The hypothesis that an increase in ETR is positively correlated with the financial assets of commercial banks was rejected. According to the results, a 1% increase in ETR would increase debt assets by about 15% in Poland and an increase in equity assets by 32%. In the case of Czechia, Slovakia and Hungary, results showed the opposite impact; thus, an increase in ETR would lead to a reduction in debt assets (7.34% in the Czech Republic, 0.64% in Slovakia, 4.55% in Hungary) and an increase in equity assets (3.01% in CZ, 1.21% in SK, 252% in HU).

ROA – ETR

Our results show a positive (8.89%) but insignificant relationship between ETR and bank rentability. Empirical studies assume a statistically significant correlation between these variables; however, they diverge on whether the correlation is positive or negative. Richardson and Lanis (2007), Liu and Cao (2007), and Armstrong et al. (2012) confirmed a positive relationship. Thus, more profitable companies achieve a higher level of ETR. The contrary argument to our assumption made by Manzon and Plesko (2001), Schandlbauer (2017), Kohlscheen et al. (2018), Gallemore et al. (2017), Mahenthiran and Kasipillai (2012) which confirmed that a higher taxable income declines level of ETR.

Debt and equity assets – ETR

Empirical research supports the hypothesis that ETR depends on the volume of financial assets. Our model showed a negative and statistically insignificant correlation between ETR and debt assets (−16.82%) and a positive correlation between ETR and equity assets (7.34%). However, studies assumed the opposite view. Thus, a higher volume of equity assets leads to a lower ETR. Studies by Chen et al. (2010) and Delgado et al. (2014) agree with our results and state that deductible debt expenses cause a negative correlation of debt assets. Feeny et al. (2005) and Wilkinson et al. (2001) consider that ETR and equity assets are positively correlated, while Fernández-Rodríguez and Martínez-Arias (2014) did not confirm any significant relationship.

NII – ETR

The influence of ETR on NII in our model was statistically insignificant and negative (−8.02%). In the literature, evidence about this relationship is not clear. Gallemore et al. (2017) confirmed that, on average, ETR and interest income are negligibly correlated. However, they stated a positive correlation between a recession and a financial institution with a low credit rating. Gawehn (2019) assumed a positive impact, while Masiukiewicz and Dec (2012) found an inverse impact of tax rates on banks' interest income.

GPD growth – ETR

In our analysis, a change in ETR on economic growth was positive (4.56%). Generally, studies assume a positive impact of ETR on fiscal policy. However, it is not clear if this impact is positive or negative. Studies such as Claessens and Laeven (2005), Hau (2006), Baltagi et al. (2006), and Chaudhry et al. (2015) argue negligible statistical significance. Gaston and Song (2014) confirmed a significant negative impact on economic development. Gechert and Heimberger (2022) conclude that the ambiguous effect of corporate taxes on economic growth depends on several factors, such as methodology choice, econometric methods, periods, data sets, or economic theory.

Cost-income ratio – ETR

Analysing the correlation between ETR and cost-income ratio, we found a small negative impact (−1.09%). In contrast to our results are findings by Burger and Moormann (2008), Slemrod (2004), Hanlon and Heitzman (2010), and Fiordelisi et al. (2011). They stated a significant positive correlation between these variables. Thus, if ETR declines, companies report lower operational costs in their profit and loss statements. On the other hand, Richardson and Lanis (2007), Nicodème (2002), Gilson and Schizer (2003), and Shevlin et al. (2017) presumed that a higher ETR in one country would lead to capital transfers in another one with a lower effective rate to optimise costs.

Statutory tax rate – ETR

We obtained evidence that the correlation between ETR and STR was insignificant and

positive (3.51%), which corresponds with findings by Claessens and Laeven (2005) and Gaston and Song (2014). Authors Dias and Reis (2018), Andrejovska (2019), and Inkabova et al. (2021) analysed differences between these rates and proved that the higher the STR, the smaller the increase in ETR. Vella (2015) pointed out that significant differences between tax rates lead to speculative optimising strategies and, thus, excessive tax evasion in a country. Fernández-Rodríguez et al. (2021) find that STR has no effect on ETR in emerging economies.

Inflation rate – ETR

Our results showed that an increase in ETR will lead to a decline in the inflation rate (−3.38%). This conclusion contrasts Spengel et al. (2016) and Immervoll (2000). They stated an insignificant positive correlation that depends on other economic factors (e.g., economic recession, expansion, or tax system).

Tab. 5: Effect of ETR in Slovakia (2007–2019)

Slovakia	Coefficients	St. error	*t*-stat	*p*-value
ROA	−14.7381	6.2070	−2.3744	0.0981
log Debt assets	−0.6940	19.7163	−0.0352	0.9741
log Equity assets	1.2078	4.3014	0.2808	0.7971
NII	1.1950	5.7588	0.2075	0.8489
CIR	0.1416	0.2002	0.7073	0.5304
log GDP	12.7608	24.1246	0.5290	0.6335
NTR	1.2197	1.0354	1.1780	0.3237
Inflation rate	−0.8881	1.0192	−0.8713	0.4477
GFCF	0.6999	0.9810	0.7135	0.5270

Note: N = 13; R^2 = 0.8348; adj. R = −0.3393; st. error = 2.8171; SS = 120.33; MS = 13.37; F-test = 1.6848; p-value = 0.3652.

Source: own

Tab. 6: Effect of ETR in Czechia (2007–2019)

Czechia	Coefficients	St. error	*t*-stat	*p*-value
ROA	−1.221	11.858	−0.103	0.925
log Debt assets	−7.345	20.437	−0.359	0.743
log Equity assets	3.001	27.541	0.109	0.920
NII	−1.945	2.669	−0.729	0.519
CIR	0.124	0.224	0.552	0.619
log GDP	−1.148	25.890	−0.044	0.967
NTR	−3.833	1.359	−2.820	0.067
Inflation rate	0.234	0.751	0.311	0.776
GFCF	0.298	2.008	0.149	0.891

Note: N = 13; R^2 = 0.9358; adj. R = 0.7435; st. error = 1.3449; SS = 240.76; MS = 26.75; F-test = 4.8650; p-value = 0.1099.

Source: own

Tab. 7: Effect of ETR in Poland (2007–2019)

Poland	Coefficients	St. error	*t*-stat	*p*-value
ROA	25.4780	5.5743	4.5706	0.0196
log Debt assets	15.4020	6.7089	2.2958	0.1054
log Equity assets	−32.2722	8.7335	−3.6952	0.0344
NII	−1.6550	2.0001	−0.8275	0.4686
CIR	0.5662	0.2007	2.8213	0.0667
log GDP	103.4366	21.7048	4.7656	0.0175
NTR	0.0030	0.0063	0.4794	0.6486
Inflation rate	−2.8131	0.5684	−4.9492	N/A
GFCF	−0.5317	0.7245	−0.7339	0.5161

Note: N = 13; R^2 = 0.9943; adj. R = 0.9773; st. error = 1.5055; SS = 1,195.98; MS = 132.88; F-test = 58.6294; p-value = 0.0032.

Source: own

Gross fixed investments – ETR

In the case of a relationship between ETR and fixed investments, we found out small negative correlation (−0.98%). Alves (2018) confirmed a negative correlation between ETR and investment dynamics from a short-term and long-term perspective. Our result corresponds to a study by Goda and Ballesteros (2020) and Farah et al. (2021), which confirmed that there is not any significant correlation between these variables. Foreign direct investments and the openness of an economy rather explain this correlation.

As we see in Tab. 5, in Slovakia was found a negative impact of ETR on ROA (−14.74%) and inflation rate (−0.89%) and a positive impact on NII (1.20%), cost-income ratio (0.14%), GDP growth (12.76%), statutory rate (1.22%) and fixed investments (0.70%).

As can be seen in Tab. 6, in Czechia was confirmed a stronger negative impact of ETR

Tab. 8: Effect of ETR in Hungary (2007–2019)

Hungary	Coefficients	St. error	*t*-stat	*p*-value
ROA	36.8894	40.3552	0.9141	0.4281
log Debt assets	−454.9896	471.9460	−0.9641	0.4061
log Equity assets	252.7688	283.3013	0.8922	0.4380
NII	−66.9480	50.9181	−1.3148	0.2800
CIR	−9.2458	4.8614	−1.9019	0.1533
log GDP	−503.2355	520.8111	−0.9663	0.4052
NTR	−5.5322	15.3774	−0.3598	0.7429
Inflation rate	−11.2036	18.1952	−0.6157	0.5816
GFCF	1.8061	17.9934	0.1004	0.9264

Note: N = 13; R^2 = 0.7122; adj. R = −0.1510; st. error = 70.4634; SS = 36,867.11; MS = 4,096.34; F-test = 0.8250; p-value = 0.6398.

Source: own

on rentability (−1.22%), NII (−1.94%), statutory rate (−3.83%) and GDP growth (−1.15%). The negligible positive effects of the increase in ETR by 1% were on the cost-income ratio (0.12%), inflation rate (0.23%) and fixed investments (0.30%).

The analysis showed a statistically significant correlation in Poland (Tab. 7). Thus, a 1% increase in ETR would lead to an increase in rentability (25.50%), cost-income ratio (0.57%) and GDP growth (up to 103%). A negative trend was observed in NII (−1.65%), inflation rate (−2.81%) and fixed investments (−0.53%), while the statutory rate had a negligible impact.

In Hungary, the results were strongly affected by wide variations of ETR due to political choices (Tab. 8). According to data, an increase in ETR would have a strong negative impact on all factors except rentability (36.89%) and fixed investments (1.81%).

The individual analysis of regression coefficients showed a negative impact of ETR increase on debt assets, interest income and cost-income ratio, and an inverse relationship between ETR and inflation rate and fixed investments. The positive impact did have a change of ETR on bank rentability on assets, equity assets, and statutory rate and GDP growth (Tab. 9).

Tab. 9: Individual effects of ETR in V-4 Group (2007–2019)

Individual effects	Coefficients	St. error	*t*-stat	*p*-value
ROA	8.8956	9.6536	0.9215	0.3621
log Debt assets	−16.8271	14.2920	−1.1774	0.2457
log Equity assets	7.3354	10.2280	0.7172	0.4772
NII	−8.0236	6.3937	−1.2549	0.2164
CIR	−1.0883	0.5136	−2.1192	0.0400
log GDP	4.5635	3.1070	1.4688	0.1493
NTR	3.5084	2.2218	1.5791	0.1218
Inflation rate	−3.3765	2.7751	−1.2167	0.2305
GFCF	−0.9875	2.4953	−0.3957	0.6943

Note: $N = 52$; $R^2 = 0.1868$; adj. $R = -0.0126$; st. error = 32.3150; SS = 10,078.23; MS = 1,119.80; F-test = 1.0723; p-value = 0.4025.

Source: own

Conclusions

The study dealt with the effective tax rate in commercial banks in the V-4 Group. The banking sector in these countries in 2007–2019 was characterised by some common attributes, e.g., strong correlation with macroeconomic development in the EU, reaction to the financial crisis, and stability in the financial market. The differences were seen in the political situation in Hungary (excessive bank taxation, devaluation of the national currency, drop in bank rentability, reduction of the statutory rate at 9%).

Our assumption that an increase in ETR would lead to an increase in financial assets was not confirmed. Therefore, we rejected the null hypothesis. Results of the regression analysis showed that, in general, an increase in ETR by 1% leads to an increase in equity assets by 7.34% and a reduction of debt assets by 16.83%. However, the results were not statistically significant. For individual countries, results were significant only in Poland, where a 1% change in ETR would increase debt assets by 15.4% and a reduction in equity assets by 32.27%. On the other hand, in Czechia, Slovakia and Hungary, statistically insignificant results proved only the assumption about the negative impact of ETR on debt assets

(7.34% in CZ, 454% in HU, 0.69% in SK) and positive impact on capital assets (3.01% CZ, 252% HU, 1.21% SK). The observation suggests a stronger positive impact of ETR on rentability and equity assets, on the other hand, a negative effect on debt assets, net interest income and cost income ratio.

We suggest that special emphasis should be placed on the relationships between ETR and all items of financial assets in the balance sheets of commercial banks in all EU Member States. It should consider the period before 2017 with the present period to determine the effect of the new international accounting standard for financial instruments on taxable income and tax expenditure. Our research necessitates improving the methodology used. We want to examine ETR in the EU by cluster analysis to determine groups of European banks according to the structure of assets and liabilities and to compare them from an investment decision perspective. Furthermore, we would like to use difference-in-difference analysis to determine the effect of ETR and accounting standards on commercial banks' balance sheets.

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A comparative analysis of multivariate approaches for data analysis in management sciences

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Abstract: *The researchers use the SEM-based multivariate approach to analyze the data in different fields, including management sciences and economics. Partial least square structural equation modeling (PLS-SEM) and covariance-based structural equation modeling (CB-SEM) are powerful data analysis techniques. This paper aims to compare both models, their efficiencies and deficiencies, methodologies, procedures, and how to employ the models. The outcomes of this paper exhibited that the PLS-SEM is a technique that combines the strengths of structural equation modeling and partial least squares. It is imperative to know that the PLS-SEM is a powerful technique that can handle measurement error at the highest levels, trim and unbalanced datasets, and latent variables. It is beneficial for analyzing relationships among latent constructs that may not be candidly witnessed and might not be applied in situations where traditional SEM would be infeasible. However, the CB-SEM approach is a procedure that pools the strengths of both structural equation modeling and confirmatory factor analysis. The CB-SEM is a dominant multivariate technique that can grip multiple groups and indicators; it is beneficial for analyzing relationships among latent variables and multiple manifest variables, which can be directly observed. The paper concluded that the PLS-SEM is a more suitable technique for analyzing relations among latent constructs, generally for a small dataset, and the measurement error is high. However, the CB-SEM is suitable for analyzing compound latent and manifest constructs, mainly when the goal is to generalize results to specific population subgroups. The PLS-SEM and CB-SEM have specific efficiencies and deficiencies that determine which technique to use depending on resource availability, the research question, the dataset, and the available time.*

Keywords*: Partial least square-SEM (PLS-SEM), covariance-based-SEM (CB-SEM), SEM-based multivariate approach, multiple manifest variables, PLS-SEM vs. CB-SEM modeling.*

JEL Classification: *C8, C42, C52.*

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Introduction

The researchers use covariance-based structural equation modeling (CB-SEM) and partial least square structural equation modeling (CB-SEM) to analyze the data of complicated connections among the latent and manifest constructs (Ahmed et al., 2021; Hair et al., 2022). Still, there are some vital differences between the two multivariate techniques; for example, PLS-SEM and CB-SEM modeling handle collinearity differently (Ahmed et al., 2022; Hair et al., 2019; Sarstedt et al., 2019). However, the PLS-SEM is very beneficial for managing data with a high degree of collinearity because it divides the data into latent variables uncorrelated using the PLS-SEM method (Sarstedt et al., 2022). On the other hand, the CB-SEM modeling is founded on multivariate normality and necessitates the data to be uncorrelated, as highlighted by Lu et al. (2020) and Hair Jr. et al. (2017). When the data is highly correlated, CB-SEM may generate unreliable or inconsistent results (Becker et al., 2022; Legate et al., 2022). Another difference is how the models are estimated, as Sarstedt et al. (2019) demonstrate. The PLS-SEM modeling uses a technique called bootstrapping to estimate the model parameters. This method can be computationally intensive but allows for a trustworthy approximation of factors in the presence of outliers and non-normality. The CB-SEM uses maximum likelihood approximation, which is computationally efficient but may not work well with non-normal data or outliers, according to Hair Jr. et al. (2017) and Mueller and Hancock (2018). The CB-SEM bases its assumptions on the multivariate normality hypothesis and demands that the data be uncorrelated (Ahmed et al., 2021; Hair et al., 2019; Hayes et al., 2017). For handling data with non-normality, outliers, and missing values, the PLS-SEM is not based on distributional assumptions and is, therefore, more flexible (Ringle et al., 2022; Sarstedt & Cheah, 2019). In light of this, it has been proven by Hwang et al. (2020), Ringle et al. (2015), and Hair et al. (2018) that PLS-SEM is a more reliable and adaptable method for assessing complex and correlated data than CB-SEM, which is based on multivariate normality assumptions. However, the technique chosen depends on the goals, research questions, and dataset characteristics (Hair et al., 2022). The CB-SEM and PLS-SEM are multivariate methodologies, but each has strengths and weaknesses.

The PLS-SEM is a statistical technique that combines the benefits of structural equation modeling partial and least squares to evaluate complex associations between latent variables and observable datasets, as highlighted by Sarstedt et al. (2019), and Ahmed et al. (2022). The PLS-SEM is particularly helpful in handling data with a high degree of collinearity since it uses the PLS-SEM technique to break the dataset down into uncorrelated latent variables. The PLS-SEM employs a more suitable parameter estimation technique for examining the model's parameters in the presence of outliers and non-normality (Memon et al., 2019). PLS-SEM has excellent flexibility because it does not rely on distributional assumptions and can handle data with non-normality, outliers, and missing values, according to Hair et al. (2010) and Sarstedt et al. (2021). The PLS-SEM technique can estimate latent variables that symbolize unobserved or underlying constructs in the data (Hair & Sarstedt, 2021; Legate et al., 2022). The PLS-SEM technique permits the study of numerous groups/subpopulations in the data, which can help compare groups or measurement invariance tests. According to Sarstedt et al. (2019) claim, the PLS-SEM can also handle correlations between constructs that are not linear. The PLS-SEM enables an understanding of the interactions between constructs by providing details on the intensity and direction of the associations and the comparative significance of each construct in the considered model (Legate et al., 2022). The PLS-SEM analysis can be performed using various programs, including the Smart-PLS, Warp-PLS, XLSTAT, and R packages for PLS-SEM (Memon et al., 2019; Parmar et al., 2022). Hence, it can be supposed that the PLS-SEM is an effective technique for evaluating complex, highly connected data since it enables the modeling and handling of non-linear relationships in a robust, flexible, and understandable manner (Hair et al., 2014; Hair et al., 2019).

The CB-SEM is used by Hayes et al. (2017) and Lu et al. (2020) to examine a complicated relationship between latent constructs and observable data. The CB-SEM uses maximum likelihood approximation to estimate the model parameters, which is computationally efficient as one of its essential characteristics (Ahmed et al., 2022; Hooper et al., 2008). Given that the CB-SEM technique is founded on the assumptions of multivariate normality,

an uncorrelated dataset is needed (Hair et al., 2018). Latent variables, or unseen or underlying constructs in the data, can be estimated using CB-SEM (Hair et al., 2011; Hooper et al., 2008). The CB-SEM offers many fit indices that could be employed to examine the model fit and spot any potential issues under consideration (Bentler, 1990). Several groups or subpopulations can be analyzed using CB-SEM, allowing for comparing groups or testing invariance measurements (Sarstedt et al., 2021). According to Sarstedt et al. (2019) and Rigdon (2016), the CB-SEM enables model adjustment by introducing or eliminating latent structures or routes. Various softwares are available for CB-SEM analysis, including AMOS, LISREL, and M-Plus (Becker et al., 2022; Hair et al., 2018). By providing details on the strength and direction of the link and the relative prominence of each construct in the model under consideration, CB-SEM enables the analysis of relationships between variables (Parmar et al., 2022). Thus, it is debated that CB-SEM is a statistical methodology using the computationally effective maximum likelihood method to examine the model's parameters. It is predicated on multivariate normalcy and necessitates the absence of correlation in the data. Additionally, it offers many goodness-of-fit statistics, allows for model adjustment and estimation of latent variables, and makes software available (Hair et al., 2014).

This paper's goal is to assess and contrast PLS-SEM vs. CB-SEM modeling. This study may be helpful to future researchers, who may use it to decide which approach to use under particular circumstances. The CB-SEM and PLS-SEM multivariate approaches are also covered comprehensively in this study. The CB-SEM and PLS-SEM multivariate approaches have also been described in earlier research, but that literature does not discuss every aspect of both multivariate techniques (Becker et al., 2022; Hair et al., 2019; Legate et al., 2022; Ringle et al., 2022), and several other studies, which had several drawbacks. Previous literature, for instance, does not address several features, such as sample size, multicollinearity issues, components, types of CB-SEM and PLS-SEM, model fit indices, measurement, and structural models. The current study provides an in-depth analysis of the CB-SEM and PLS-SEM multivariate techniques' features, benefits, shortcomings, and methodology.

The remaining sections of the paper are divided into numerous sections, such as section 2 (Theoretical Background), section 3 (Research methodology), section 4 (Results and discussion), section 5 (Conclusions), and Limitations and future research orientations.

1. Theoretical background

Previous literature has explored the difference between PLS-SEM and CB-SEM modeling. The literature differentiated their categories and demonstrated the efficiencies and deficiencies of both models (Hair et al., 2006; Hair & Sarstedt, 2021). Several studies have demonstrated that PLS-SEM is an SEM to explore complex relationships between numerous parameters (Hair et al., 2022; Henseler et al., 2015). Similarly, previous literature exhibited that CB-SEM models could be used depending on the research goals, research questions, and data arrangements. PLS-PM (PLS path modeling) is a PLS-SEM variant used to evaluate associations between observed and unobserved elements in the model and to estimate the path coefficients connecting these variables. PLS-SEM and CB-SEM modeling come in a multiplicity of different forms (Memon et al., 2019; Ringle et al., 2015). According to Hair et al. (2022) and Sarstedt and Cheah (2019), PLS-CFA (PLS-confirmatory factor analysis) is used to gauge theories about the structure of the measurement model, including theories about the number of components, factor loadings, and measurement errors. The PLS-SEM is a method to estimate the path coefficients between constructs and investigate associations between unobserved elements in a model (Ringle et al., 2022). PLS-regression is accustomed to evaluating the association among predetermined predictors of a construct of interest, such as a dependent variable (Hair & Sarstedt, 2021; Legate et al., 2022). By identifying the linear blend of components that maximizes the covariance among constructs, PLS-canonical analysis is used to categorize the underlying structure of a dataset, as demonstrated by Richter et al. (2020) and Hair et al. (2017). A set of data is divided into groups using PLS-DA (PLS-discriminant analysis), a kind of PLS-SEM grounded on the values of predictors (Hair et al., 2022). PLS-SEM with small data is the type of PLS-SEM that is very helpful when several constructs are more incredibly associated with a small sample size; missing

data, non-normality, and multicollinearity can all be accommodated by it (Matthews, 2017; Ringle et al., 2015).

According to previous studies, there are other varieties of CB-SEM modeling, including confirmatory factor analysis, a sort of CB-SEM accustomed to testing a considered measurement model based on fixed latent variables and preset manifest factors (Ahmed et al., 2022; Hair et al., 2022). It could support or disprove a scale's or measure's factor structure (Hair et al., 2010; Hussain & Ahmed, 2020). Path analysis assesses the direction, strength, and correlation between various parameters. It can evaluate theories of causal relationships between many components (Hayes et al., 2017). This kind of CB-SEM, known as latent growth curve modeling (LGCM), looks at how variables change over time. Examining a variable's rate of change and its consistency across time is a common practice (Hair et al., 2011). Grounded on the provisions of answers to a set of observed factors, latent class analysis (LCA) is frequently used to ascertain subdivisions or classes within a population (Nunkoo et al., 2020). The CB-SEM method, known as multigroup SEM, compares an association among constructs across various groups or populations. It can be used to look for variations or patterns in the relationships between variables between various groups (Cohen, 1992; Hayes et al., 2017). This kind of CB-SEM, SEM with missing data, deals with missing data in the analysis. It is customary to look at the parameters of the model and missing data simultaneously (Hair et al., 2006). SEM without normality data is the type of CB-SEM that works with non-normal data for the analysis. Using reliable estimating approaches, the model's parameters could be evaluated (Henseler et al., 2015).

According to Ringle et al. (2015) and Hair et al. (2010), the sample size for PLS-SEM should be sizable to ensure adequate power for the statistical analysis and to obtain a suitable level of generalizability (Hair et al., 2010; Ringle et al., 2015). However, PLS-SEM sample size recommendations are less accurate than those for traditional SEM (Sharma et al., 2021). PLS-SEM is considered a more reliable method than traditional SEM regarding sample size and measurement error because it can tolerate higher levels of measurement error (Ahmed et al., 2019; Hair et al., 2019). As a result, PLS-SEM frequently has more flexible sample size requirements than typical SEM. It is vital to keep in mind that sample size is always determined by the study purpose, the resources available, and the amount of time available, even if some studies have shown that PLS-SEM may be employed with datasets as low as 50–100 instances (Hayes et al., 2017).

Previous literature also discussed the required sample for PLS-SEM modeling; according to Hussain and Ahmed (2020), Hussain et al. (2021), and Zaidi et al. (2022), the sample size required to achieve a specific power level, for instance, 80% or 90%, can be determined in various ways, including simulation studies and power analysis techniques. The sample size is calculated considering the research topic, the resources available, and the amount of time available. It is crucial to remember that sample size estimations are frequently approximate. It is also critical to remember that the PLS-SEM sample size requirements vary depending on the number of predictors and model complexity (Sarstedt & Cheah, 2019). As models become more complicated, sample sizes become more critical. The sample size must be proficient at ensuring the accuracy and objectivity of the estimated values (Shmueli et al., 2019). Similarly, previous literature also discussed that the sample size is a vital concern in the CB-SEM technique since it can affect the valuation of the considered model's parameters and the model's capacity to fix the dataset. A larger sample size will produce more precise parameter estimates and a better model-data fit (Hair et al., 2014; Sharma et al., 2021).

According to Hair et al. (2011), the optimal sample size will depend on the complexity of the model, the number of indicators, the latent factors quantity, and the level of measurement error. There are numerous methods for computing the sample size for the CB-SEM. The recommendations for the sample size for the CB-SEM depend on various aspects, among them the number of factors, the number of estimated parameters, and the amount of measurement error (Hair et al., 2011). One of several recommended sample size criteria is the "10:1 rule", which describes that the sample size must be ten times the parameters, which has to be evaluated. This rule, though, only functions under certain circumstances (Hussain & Ahmed, 2020; Streukens & Leroi-Werelds, 2016). Power analysis techniques or simulation studies can be used to calculate

the sample size required to attain a given power level, for instance, 80% or 90%, to establish the sample size that provides a high likelihood of detecting a particular effect. In general, SEM requires a sample size of 200 or more. However, this guideline might only apply to particular models; thus, employing more sophisticated sample size estimation techniques is always a good idea.

According to Kang (2021) and Hoenig and Heisey (2001), power analysis can decide the desired sample size to identify a particular effect size at a specific power level. Power analysis can consider the magnitude of measurement error, the complexity of the model, and the number of indicators. Simulators de Monte Carlo – this method simulates data and figures out the sample size necessary to accurately estimate model parameters (Hayes et al., 2017; Kroese et al., 2014). It can be accomplished by relating the Akaike information criterion (AIC) or the Bayesian information criterion (BIC) for various sample sizes. It is crucial to remember that sample size is only one consideration when evaluating the fit of a model. Several additional elements, for instance, the number of indicators, the considered model's complexity, the data distribution, and the estimation method, impact the model fit (Hoenig & Heisey, 2001).

Previous literature demonstrated that multicollinearity is a common problem in PLS-SEM and CB-SEM, which occurs when two or more predictor variables are closely associated (Grewal et al., 2004). It occurs when two or more independent variables exhibit strong correlations, and estimating models and explaining their results can be challenging (Wondola et al., 2020). For example, a correlation matrix can determine how every independent construct connects with others to find multicollinearity in PLS-SEM and CB-SEM. Multicollinearity may be present if there is a significant correlation between two or more independent constructs (Wondola et al., 2020). The degree of multicollinearity in a multiple regression model is measured by the variance inflation factor (VIF). The VIF of 1 shows the absence of multicollinearity, while a VIF bigger than 1 specifies the occurrence of multicollinearity. High multicollinearity is frequently indicated by a VIF more significant than five (Chan et al., 2022; Hussain & Ahmed, 2020). The variance amount in a predictor, which other predictors cannot describe, is represented by tolerance, which is the reciprocal of VIF. There is high multicollinearity when the tolerance value is below 0.2. The condition index gauges the level of multicollinearity in a multiple regression model. Multicollinearity is indicated by a number higher than 30 (Arminger & Schoenberg, 1989; Chan et al., 2022). The previous literature has discussed and identified several positive and negative aspects of PLS-SEM and CB-SEM techniques, however, numerous factors are still missing to establish the differentiation between both modeling techniques, thus the current study answers those questions.

2. Research methodology

2.1 Research design and estimation techniques

The undertaking is a comparative study, which has differentiated PLS-SEM and CB-SEM modeling; the study also considers the efficiencies and deficiencies of both models in the management sciences field. The comparative studies could be performed qualitatively or quantitatively. However, the research design of this study is qualitative, and researchers have stated the pros and cons of PLS-SEM and CB-SEM techniques; they also compare different parameters of both techniques. This study has used previous literature and thoroughly reviewed previous studies, books, and other relevant publications to analyze both models. This study also used graphical analysis to distinguish between PLS-SEM and CB-SEM modeling.

The study examined the criteria to validate measurement models, such as convergent and discriminant validities, using factor loading of items, Cronbach's alpha, composite reliability, and average variance extracted of constructs to validate the convergent validity and reliability in both PLS-SEM and CB-SEM techniques. Moreover, this study analyzed HTMT, Fornell-Larcker criterion, and cross-loading to validate discriminant validity for both SEM techniques. Similarly, this study also examined the parameters for validating a structural model for PLS-SEM modeling. For this purpose, the researchers used the coefficient of determination (R^2), effect size (f^2), path coefficient analysis (direct, indirect relationship of constructs), goodness of fit measures, and predictive relevance (Q^2).

This research used confirmatory factor analysis, structural equation modeling, path coefficient analysis (direct, indirect relationship of constructs), and goodness of fit measures

to validate structural models in CB-SEM techniques. This study also used the graphical analysis to examine the observed, unobserved, convergent, and discriminant validity to endorse the measurement model for both PLS-SEM and CB-SEM techniques. The graphical analysis also defined the path coefficient relationship (direct and indirect relationship of constructs) to validate the structural model for both PLS-SEM and CB-SEM techniques.

2.2 Acronyms and full names

Tab. 1 exhibited the acronyms and full names of different abbreviations used in this paper.

Tab. 1: Acronyms and full names

Acronyms	Full names	Acronyms	Full names
PLS-SEM	Partial least square structural equation modeling	**PLS-CFA**	Partial least square confirmatory factor analysis
CB-SEM	Covariance-based structural equation modeling	**PLS-DA**	Partial least square discriminant analysis
SEM	Structural equation modeling	**LGCM**	Latent growth curve modeling
Smart-PLS	Smart partial least square software	**LCA**	Latent class analysis
Warp-PLS	Variance-based and factor-based structural equation modeling software	**SRMR**	Standardized root mean square residual
XLSTAT	Excel statistical software	**HTMT**	Heterotrait monotrait ratio of correlation
AMOS	Analysis of moment structures	**AVE**	Average variance extracted
LISREL	Linear structure relations	**D_ULS**	The squared euclidean distance
M-Plus	Microdia plus software	**AGFI**	Adjusted goodness of fit index
RMSEA	Root mean square error of approximation	**RNI**	Relative non-centrality index
CFI	Comparative fit index	**PCFI**	Parsimonious-adjusted fit index
GFI	The goodness of the fit index	**PNFI**	Parsimony-adjusted normed fit index
TLI	Tucker Lewis index	**G_D**	Geodesic distance
NFI	Normal fit index	**VIF**	Variance inflation factor

Source: own

3. Results and discussion

The results of this study demonstrated the parameters of the measurement and structural models for both PLS-SEM and CB-SEM techniques.

3.1 The measurement model in CB-SEM and PLS-SEM modeling

In PLS-SEM & CB-SEM modeling, validating the measurement model entails evaluating the fitness of the dataset and the reliability of indicators chosen to represent the latent variables (Hair et al., 2019). This procedure includes the following steps as the factor loadings indicate how intensely indicators and unobserved factors are linked. Significant factor loadings show that the indicators and latent variables are closely connected (Hair et al., 2014; Rigdon, 2016). Factor loadings have a conventional cut-off of 0.7, which can change depending on the research environment (Ringle et al., 2015). The measuring model must be validated by evaluating the indicators' reliability and validity. While validity narrates how well the indicators measure the latent variable, reliability

refers to the indicators' consistency across time (Byrne, 2013; Ringle et al., 2015).

The model must offer a good match for the dataset; in PLS-SEM modeling, several fit indices, including R^2 and Q^2, can be applied to measure how well the model fixes the dataset. These indices show the percentage of the variance in outcome constructs the model justifications (Henseler et al., 2015; Parmar et al., 2022). Similarly, many fit indices, including the RMSEA, chi-square statistic, and comparative fit index (CFI), can be applied to measure the model's fitness in CB-SEM modeling (Hooper et al., 2008). The importance of path coefficients and the overall model should be tested by examining the structural model (Bentler & Bonett, 1980; Hair et al., 2022).

Suppose the factor loadings or the model do not match the data well. In that case, it may be essential to re-specify the model by modifying the path coefficients, adding or removing variables, or making other modifications (Sarstedt et al., 2022). It is essential to remember that measurement model validation is an iterative process, and the model should be refined and re-evaluated as needed until an acceptable level. It is crucial to remember that when working with CB-SEM, using multiple data sources, such as self-report surveys, behavioral observations, and physiological measures, can increase the rationality of the measurement model. Additionally, the validation process should be done with the sample used in the study and not just in the population in general (Hair et al., 2014). The annotated graphical form of the measurement model of PLS-SEM is provided in Fig. 1 (Ahmed et al., 2021). Fig. 1 demonstrated that the factor loadings of each item are higher than 0.70, and the average variance extracted is more significant than 0.50, which fulfilled the convergent validity requirement. Moreover, the path analysis between the construct validated the discriminant validity; thus, this endorsed the measurement model.

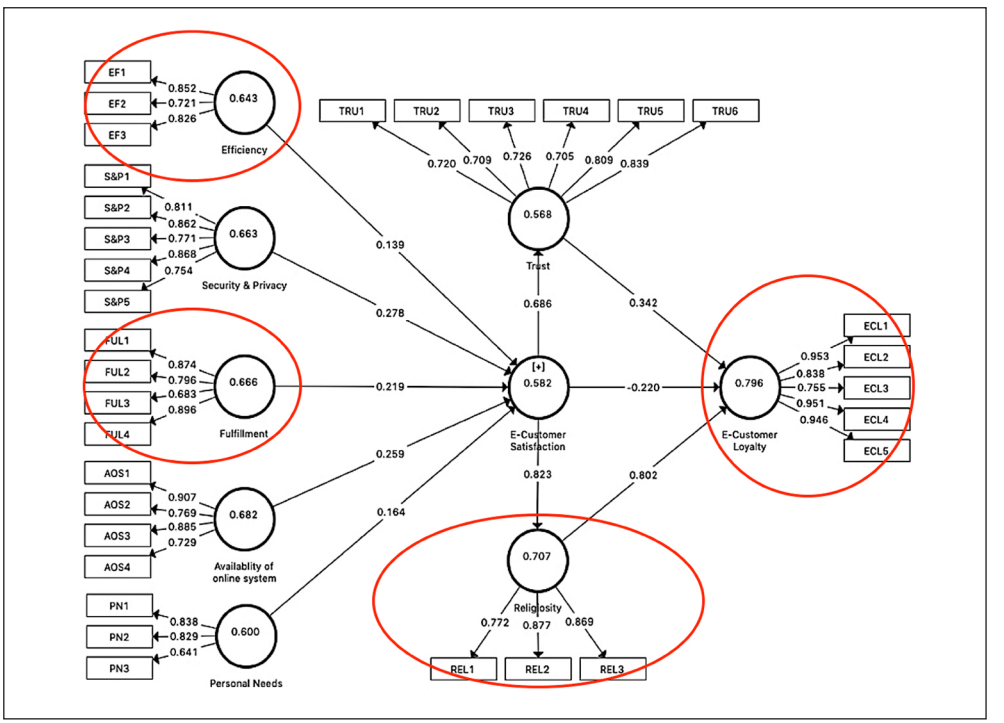

Fig. 1: Measurement model in PLS-SEM modeling

Source: Ahmed et al. (2021)

The annotated graphical form of the measurement model of CB-SEM is provided in Fig. 2 (Ashraf et al., 2018). Fig. 2 also demonstrated that each observed variable has a factor loading of more than 0.70, values of path coefficient between the unobserved variables, and values of goodness of fit measures have followed the cut-offs. Thus, Fig. 2 demonstrates that the measurement model is validated in CB-SEM modeling.

3.2 The structural model in CB-SEM and PLS-SEM modeling

In CB-SEM and PLS-SEM modeling, validating the structural model entails analyzing the model's fitness to the dataset, determining the importance of the path coefficient, and reviewing the overall model (Kline, 2015). This procedure includes several steps; for example, the path coefficients show how strong and in what direction the latent variables are related. High positive path coefficients indicate a strong positive relationship between the latent variables, while high negative path coefficients indicate a strong negative relationship (Hair et al., 2019; Raza et al., 2021). *T*-tests or bootstrapping techniques can be used to conclude the significance of the path coefficients. If the path coefficient is significant, the latent variables must be statistically related (Hair et al., 2014; Hayes et al., 2017; Henseler et al., 2015).

In PLS-SEM modeling, fit indices like R^2 and Q^2 could be applied to measure the overall fitness of the model. These indices indicate the variance proportion in dependent factors that the model explains (Bentler, 1990). The overall fitness of the CB-SEM model can be evaluated using fit indices such as the RMSEA, chi-square statistic, and comparative fit index (CFI; Hooper et al., 2008). Discriminant validity examines how little latent variables connect with measurements of unrelated constructs. It can

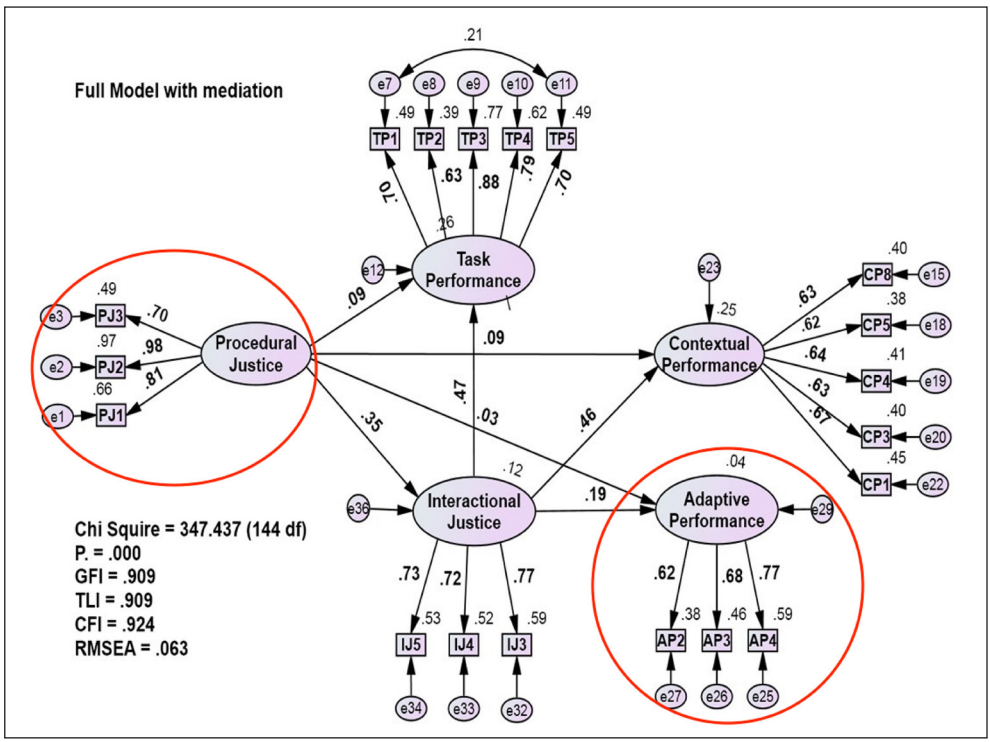

Fig. 2: Measurement model in CB-SEM modeling

Source: Ashraf et al. (2018)

be assessed by contrasting the latent variables' average variance extracted with their squared correlation to unrelated factors (Ahmed et al., 2021; Fornell & Larcker, 1981; Hair Jr. et al., 2017; Malhotra et al., 2006).

The model may need to be re-specified by adding or removing variables, changing the path coefficients, or modifying the model in other ways if it does not fit the data well or if the path coefficients are not significant (Kaufmann & Gaeckler, 2015; Sarstedt et al., 2022). It is crucial to remember that structural model validation is an iterative process. The model must be polished and reexamined until an acceptable fit level and significance are achieved (Sarstedt et al., 2019). It is essential to remember that when working with CB-SEM, using multiple data sources, such as self-report surveys, behavioral observations, and physiological measures, can increase the validity of the structural model. Additionally, the validation process should be done with the sample used in the study and not just in the population in general (Malhotra et al., 2006). The annotated graphical form depicted the structural model of PLS-SEM in Fig. 3 (Ahmed et al., 2021). Fig. 3 demonstrated the path coefficient between the constructs (direct and indirect relationship), which shows significant values; moreover, *R*-square values showed the impact of exogenous variables on endogenous variables. Thus, Fig. 3 validated the structural model in PLS-SEM modeling.

The annotated graphical shape of the structural model of CB-SEM is provided in Fig. 4 (Ashraf et al., 2018). Fig. 4 demonstrates the path coefficient between the constructs (direct and indirect relationship), which shows significant values. Moreover, fit indices values meet the required threshold. Thus, Fig. 4 validated the structural model for CB-SEM modeling.

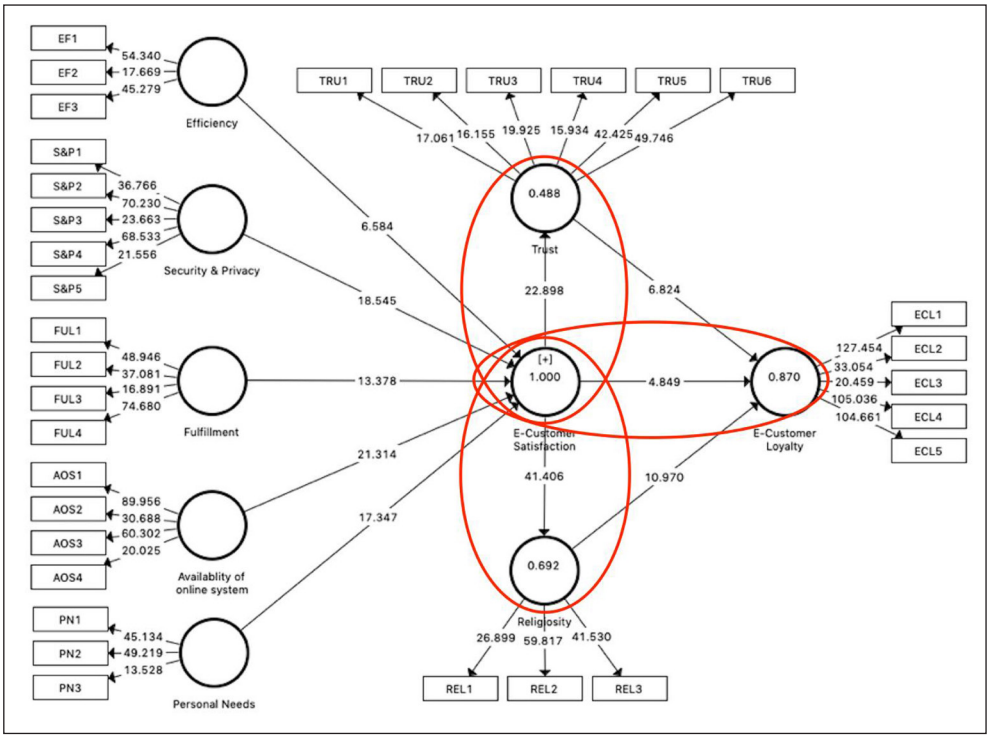

Fig. 3: Structural model in PLS-SEM

Source: Ahmed et al. (2021)

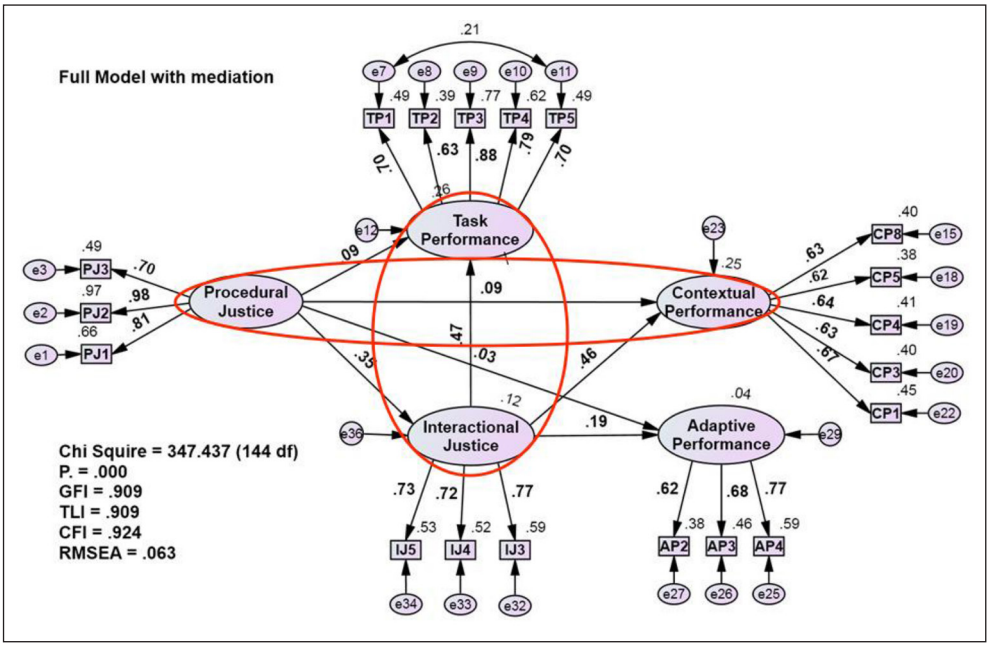

Fig. 4: Structural model in CB-SEM

Source: Ashraf et al. (2018)

3.3 Threshold values to validate the CB-SEM and PLS-SEM modeling

When validating a measurement or structural model in PLS-SEM or CB-SEM, several threshold values are commonly used to measure the accuracy, model, and reliability. Now, we have an overview of some of the most commonly used threshold values; for instance, a standard threshold for factor loadings is 0.70, but it can vary depending on the research context (Henseler et al., 2015; Kline, 2015). The typical Cronbach's alpha threshold is 0.70; however, it may change depending on the research situation (Hair et al., 2014; Miles & Shevlin, 2007).

Composite reliability depends on the research environment; the composite reliability criterion of 0.70 is typically adequate (Ringle et al., 2015). The AVE cut-off is often set at 0.50 but might change depending on the research environment. Good discriminant validity is often indicated by values higher than 0.50 (Fornell & Larcker, 1981; Hair et al., 2009).

Tab. 2: Threshold values of reliability and validity

Measures	Threshold values
Factor loading (FL)	Equal and higher 0.70
Cronbach's alpha (CA)	Equal and higher 0.70
Composite reliability (CR)	Equal and higher 0.70
Average variance extracted (AVE)	>0.50

Source: own

The typical correlation threshold is 0.70; however, it can change depending on the research circumstances. Correlations above 0.70 generally indicate a strong relationship between two variables (Hussain & Ahmed, 2020; Maydeu-Olivares et al., 2018). Tab. 2 exhibited the threshold values of factor loading, Cronbach's alpha, composite reliability, and average variance extracted.

3.4 The PLS-SEM modeling goodness of fit measures

In PLS-SEM, model fitness could be evaluated using a multiplicity of metrics, such as R^2, which gauges the proportion of the outcome construct's variance that could be accounted for by independent constructs (Hair et al., 2019). The variance amid the perceived projected covariance matrix is measured by the RMSEA, with readings nearer to 0 signifying a better fit (Hooper et al., 2008). The goodness-of-fit index (GFI) measures how considerably the variance in the observed variables can be accounted for by the model, with values nearer 1 suggesting a good fit (Hu & Bentler, 1999; Hair et al., 2019). The normal fit index (NFI), a variant of the GFI that accounts for the parameters in the considered model, has values closer to 1 than those that indicate a better fit (Ringle et al., 2022). The SRMR, a well-known measure fit of the overall model, is used in PLS-SEM. The SRMR measures the difference between observed and predicted covariance matrices. It varies from 0 to 1, where a value of 0 designates a complete fit, and a value of 1 specifies that the model cannot replicate the observed covariance matrices (Bollen & Davis, 2009). Less than 0.08 is the suggested cut-off value for the SRMR, which denotes an acceptable model fit to the dataset. However, the research field and sample size can affect the allowable value of SRMR (Ringle et al., 2015).

It is imperative to remember that SRMR is a sample-based measure calculated based on the sample, not the population. Moreover, it takes into account both structural and measurement models. It is not sensitive to the sample size; thus, it is a more robust gauge for model fit than other fit statistics such as RMSEA or CFI (Henseler et al., 2015; Kline, 2015). The CFI should be 1 for saturated models, and the RMSEA should be close to 0. It means that the model accurately describes all variations in the observed variables and is a perfect fit for the dataset (Hair et al., 2019; Mouri, 2005). RMSEA < 0.08 and CFI > 0.95 are the suggested cut-off values for estimated models. These results demonstrate that the model demonstrates the relationship among variables in the data and fits the data very well. These cut-off numbers, however, may change based on the research area and circumstance (Memon et al., 2019; Raza et al., 2021). CFI (comparative fit index) is comparable to NFI but also justifies the complexity of the model compared to a null model, with values closer to 1 suggesting a better match (Bentler, 1990; Bollen & Davis, 2009). It is worth noting that no one metric is a silver bullet, and it is consistently substantial to evaluate different metrics for different purposes (Hair et al., 2018; McDonald & Ho, 2002).

3.5 Discriminant validity in PLS-SEM

Discriminant validity in PLS-SEM refers to a construct's or latent variable's capacity to stand out from other constructs or unobserved constructs' in the considered model. It ensures that the factor measures what it intends to measure and not some other construct (Cheah et al., 2019; Raza et al., 2021). There are various techniques to evaluate the discriminant validity of PLS-SEM; for instance, the correlation ratio relates the connection between two factors to the square root of the AVE of one component. The ratio must be more significant than one to prove discriminant validity (Chin, 2010; Fornell & Larcker, 1981).

The Fornell-Larcker criterion equates the squared correlation between an indicator and the unobserved construct to the product of the unobserved construct's AVE, the indicator's squared loading on the latent variable (Cohen, 1994; Fornell & Larcker, 1981). D_ULS (discriminant validity – uniqueness) and D_G (discriminant validity – Fornell-Larcker criterion) are measures of the degree to which a factor's variance is unique, meaning other factors do not explain it in the model. A high D_ULS or D_G value indicates a construct's uniqueness, which is desirable for good discriminant validity (Franke & Sarstedt, 2019; Henseler et al., 2015).

The suggested cut-off value for D_ULS and D_G is typically more than 0.5. However, the acceptable value of D_ULS and D_G may change based on the investigation area, the size of the sample, and the research circumstances (Ringle et al., 2022). It is significant

to remember that D_G and D_ULS are not the only processes for discriminant validity. Other measures can be used, such as cross-loadings, AVE (average variance extracted), or the Fornell-Larcker criterion (Fornell & Larcker, 1981; Henseler, 2021). While these techniques can aid in establishing discriminant validity, it is essential to keep in mind that they should be used in conjunction with other approaches, for instance, Factor loading evaluation, cross-loading, correlation matrix evaluation, and model-specific theoretical construct and relationship analysis (Ahmed et al., 2020; Hult et al., 2018).

3.6 F-square values in PLS-SEM

F-square values are frequently used in PLS-SEM to measure the relative significance of predictors. The F-square value gauges how much of a dependent variable's variance each predictor contributes to (Henseler et al., 2015; Hwang et al., 2020). Each predictor in the model has an F-square value ranging from 0 to 1, with 1 denoting that the predictor fully explicates the variance in an outcome construct (Ringle et al., 2015). F-square values can be used to compare the relative weights of several model predictors. For example, a predictor with an F-square value of 0.8 would be considered more critical than one with an F-square value of 0.2 (Sarstedt et al., 2022). It is critical to remember that F-square values are relative measurements determined by the proportion of variance explicated through the model's predictors, not by the total amount of variance explicated (Ahmed et al., 2019). Moreover, PLS-regression (PLS-R) is the only version that supports it; PLS-path modeling (PLS-PM) does not (Henseler et al., 2015).

3.7 Predictive relevance (Q2) in PLS-SEM

Predictive relevance, sometimes referred to as Q^2, is used in PLS-SEM to assess the model's capacity for prediction. It is a measurement of the percentage of an outcome construct's variation that the latent constructs in the model can accurately predict (Henseler et al., 2015; Liengaard et al., 2021). The PLS-SEM model's foreseen values for an outcome variable are compared to the actual values for the dependent variable to determine Q^2. The relevant research subject and environment will determine the appropriate value of Q^2 (Hair et al., 2017; Ringle et al., 2015; Shmueli et al., 2019). It is crucial to remember that Q^2 is a relative measure, meaning that the proportion of deviation determines it explained through the model rather than the total variance (Henseler, 2021; Shi & Maydeu-Olivares, 2020). Tab. 3 indicates the interpretations of predictive relevance (Q^2) values.

Tab. 3: Predictive relevance (Q^2)

Predictive relevance (Q^2) values	Interpretations
$Q^2 = 0$	A Q^2 value of 0 means the model cannot forecast any deviation in an outcome construct
$Q^2 \geq 0.5$	Q^2 values of 0.5 or above have good predictive power in real-world applications
$Q^2 = 1$	A Q^2 value of 1 means the model can perfectly forecast all deviations in an outcome construct

Source: own

3.8 Confirmatory factor analysis (CFA) in CB-SEM modeling

A statistical technique called CFA is employed in (CB-SEM) to examine a measurement model structure. A latent variable estimate based on several indications is possible using CB-SEM. The factor structure of the indicators and the connection between the unobserved variables and the indicators are tested using CFA (Zhang et al., 2020). By contrasting the manifest covariance matrix with the projected covariance matrix based on loadings and error variances of indicators, CFA is modified to assess the measurement structure of the model in CB-SEM. If the observed and projected covariance matrices match, the model is deemed a well-fit (Raza et al., 2021).

CB-SEM also uses CFA to examine a measurement model invariance through clusters

or time. It denotes the predicted consistency of the element configuration and the link between the unobserved variables and the indicators across groups or time (Ahmed et al., 2022; Bollen & Davis, 2009). It is vital to remember that CFA is a confirmatory technique that examines a particular theory regarding the factor structure and the relationship between the unobserved variables and indicators. Also, it is crucial to note that CFA is a typical and crucial stage in CB-SEM modeling, earlier touching on the structural model component (Hair et al., 2019).

3.9 Structural equation modeling in CB-SEM modeling

CB-SEM uses structural equation modeling, a statistical approach to examine the structural links between latent and observable variables. Complex models with numerous unobserved constructs and indicators for every construct can be estimated using SEM (Ahmed et al., 2019; Hair et al., 2022). CB-SEM uses SEM to measure the structural links between the latent and observable variables by estimating the path coefficients and error variances of unobserved constructs and indicators. If the observed and projected covariance matrices match, the considered model fits well.

A range of hypotheses can be tested using CB-SEM, including those involving direct and indirect effects, mediation and moderation effects, and latent interactions. CB-SEM can also be attuned to test for measurement invariance across groups or time (Hair et al., 2019; Raza et al., 2021; Zhang et al., 2020). In order to test a specific hypothesis about the structural associations among the unobserved and observable constructs, SEM is a confirmatory method, which is essential to note. Moreover, after establishing the measurement framework and associations among the unobserved constructs, SEM is a typical and crucial stage in CB-SEM modeling (Kline, 2015).

3.10 The CB-SEM modeling goodness of fit measures

The goodness-of-fit of the measurement and structural models is measured through fit indices in CB-SEM. They indicate how well the model captures the data and can be used to pinpoint areas where the model requires improvement (Byrne, 2013; Hooper et al., 2008). Several fit indices in CB-SEM, such as χ^2/df and probability, are known as the absolute fit indices in CB-SEM modeling (Bentler & Bonett, 1980; Bollen, 1989; Lu et al., 2020). The goodness-of-fit index (GFI) indicator evaluates an association between the model's justified covariance and the data's total covariance (Byrne, 2013; Hu & Bentler, 1999). The adjusted goodness-of-fit

Tab. 4: Fit indices and threshold values

Fit-indices	Threshold values
χ^2/df and probability	χ^2/df > 5.0 and p < 0.05
GFI	Range of 0 to 1, with values around 1 (>0.95) a solid fit
AGFI	AGFI varies from 0 to 1, with a reading close to 1 (>0.95) satisfactory fit
RMSEA	<0.05 good fit, between 0.05 and 0.10 acceptable, and >0.10 poor fit
SRMR	A good fit is indicated by values less than 0.08, a good fit is shown by readings ranges 0.08–0.10, and a poor fit is indicated by readings higher than 0.10
RNI	The RNI index is 0 to 1, with values nearer 1 (>0.95), indicating a better model-to-data fit
CFI	>0.90 acceptable and >0.95 good fit
NFI	The NFI index is 0 to 1, with values nearer 1 (>0.95), indicating a better model-to-data fit
PCFI	0.75 or higher
PNFI	0.75 or higher

Source: own

index (AGFI), an amended form of the GFI, takes into account the model's independent variable count, the absolute fit indices, also known as the GFI and AGFI (Barbić et al., 2019; Bentler, 1990). The RMSEA measures the inconsistency amid the manifest and anticipated covariance matrix (Tanaka, 1993). The standard root mean square residual (SRMR) metric contrasts the model's residuals with the variances of the observed variables (Hooper et al., 2008; Ringle et al., 2015). The RNI (relative non-centrality index) fit index is a statistical metric to assess how sound a model fits a specific dataset collection. Considering the variance of the observed values, it calculates the variance amid the actual values and values forecasted through the model (Ahmed et al., 2021; Oliver, 2014). Other frequently used fit indices in CB-SEM are the comparative fit index (CFI), Trucker-Lewis index (TLI), and normal fit index (NFI). These are comparable to traditional SEM's goodness-of-fit index (GFI) and adjusted goodness-of-fit index (AGFI) (Hair et al., 2019; Raza et al., 2021; Tucker & Lewis, 1973).

To calculate PCFI (parsimonious-adjusted fit index), subtract the model's CFI from the CFI of a null model, then divide the outcome by the change in degrees of freedom between the two models (Barbić et al., 2019; Bentler, 1990; Blackwell et al., 2001; Byrne, 2013). The difference between the model's normalized fit index and the normalized fit index of a null model is used to produce the PNFI (parsimony-adjusted normed fit index), which is then divided by the variance in degrees of freedom between the two models (Hu & Bentler, 1999). It is critical to understand that many fit indices must be calibrated to estimate the model and that no single fit index is considered the best. The context of the research topic and the study's objectives must be justified while assessing the fit indices (Astrachan et al., 2014; Hair et al., 2019; Tucker & Lewis, 1973). Threshold values of fit indices are exhibited in Tab. 4.

Conclusions

The CB-SEM is a powerful technique for analyzing complex relationships among multiple variables. Both methods have advantages and disadvantages, and the approach relies on the study issue, the availability of resources, and the time available. PLS-SEM is a robust technique that can handle high levels of measurement error and can be applied to small and unbalanced datasets. It helps look at correlations between unobserved factors that are one, which could not be observed directly. When conventional SEM is not practical, PLS-SEM is especially helpful. On the other hand, CB-SEM is a powerful technique that can handle numerous groups and various signs. It helps examine connections between several manifest factors, or those that can be directly observed, and numerous latent variables (Henseler et al., 2015; Kline, 2015). CB-SEM is especially helpful when the objective is to generalize findings to specific demographic subgroups. PLS-SEM and CB-SEM are valuable tools for examining structural equation models. The study question and the characteristics of the population being investigated influence the technique selection. When selecting the best technique for their research, researchers must consider both approaches' drawbacks and underlying assumptions. The research issue and the features of the population being examined determine the theoretical implications of the comparison between CB-SEM and PLS-SEM (Ahmed et al., 2021). PLS-SEM is a data-driven approach that does not rely on a priori postulations regarding the structure of the associations among factors. Researchers can use PLS-SEM to uncover latent relationships among variables that may not be immediately apparent from the data. It can benefit researchers interested in exploring new or complex relationships among variables (Hair et al., 2022). Contrarily, CB-SEM is more theory-driven and is based on presumptions about the structure of the correlations among factors. To test particular propositions regarding the relationships between factors, researchers can employ CB-SEM. Researchers interested in putting tested theories or hypotheses to the test may find it helpful. PLS-SEM offers greater flexibility and exploration of the data, whereas CB-SEM offers greater rigor and testing of particular hypotheses. Both methods have advantages and limitations, and the choice of which technique to use depends on the characteristics of the population research question being studied (Hair et al., 2019; Zhang et al., 2020).

Additionally, PLS-SEM is more robust to multicollinearity and measurement error, which can be an issue in CB-SEM, where the assumptions of independence among the predictors and measurement invariance across groups should be met. PLS-SEM is viewed as

a more recent and less well-established technique than CB-SEM; despite this, PLS-SEM is becoming more and more well-liked and common in use, particularly in industries like marketing, psychology, and management (Ahmed et al., 2022; Hair et al., 2022). The study issue and the characteristics of the population will determine the managerial implications of the comparison between CB-SEM and PLS-SEM. PLS-SEM is a dominant procedure that can handle high measurement error levels, small and unbalanced datasets, and latent variables. PLS-SEM could be used in conditions where traditional SEM would be infeasible. Even when the sample size is unbalanced or small, and the measurement error is significant, PLS-SEM can be particularly valuable for managers and practitioners interested in understanding the underlying relationships among factors (Wondola et al., 2020). On the contrary, CB-SEM is a powerful technique that can handle numerous groups and various signs. CB-SEM can be applied when the goal is to generalize results to specific population subgroups. CB-SEM can be particularly useful for managers and practitioners interested in understanding associations between multiple unobserved and manifest factors and generalizing results to specific population subgroups. PLS-SEM offers greater flexibility and data exploration, whereas CB-SEM allows for more incredible rigors and testing of particular hypotheses, which has managerial consequences. The decision of which methodology to employ relies on the research issue and the characteristics of the population being examined. Both methods offer benefits and drawbacks (Kline, 2015). Additionally, PLS-SEM is more robust to multicollinearity and measurement error, which can be an issue in CB-SEM, where the assumptions of independence among the predictors and measurement invariance across groups should be met. It is also significant to note that PLS-SEM can be helpful in practice, particularly in industries like marketing, psychology, and management, where practitioners and researchers must deal with complicated and unbalanced datasets and where an exploratory approach is required (Henseler, 2021; Shi & Maydeu-Olivares, 2020).

Limitations and future research orientations

PLS-SEM and CB-SEM are powerful techniques for analyzing complex relationships among multiple variables; however, they also have some limitations. Some of the limitations of PLS-SEM include the following: PLS-SEM is less established and less well-known than traditional SEM, which may be less familiar to some researchers (Wondola et al., 2020). PLS-SEM does not rely on a priori suppositions regarding the structure of the relationships among the factors, making interpreting the results challenging (Hair et al., 2022). Thus, it is recommended that future researchers study this limitation. PLS-SEM is sensitive to outliers and extreme observations, which can affect the analysis results. PLS-SEM does not offer a test for overall model fit. The following are some CB-SEM drawbacks: when a priori postulations vis-à-vis the nature of interactions between the factors are not achieved, CB-SEM is used, making it challenging to interpret the results. Thus, it is recommended that future researchers carry out their studies on this topic. Another critical limitation of PLS-SEM & CB-SEM modeling is not to provide a cause-effect between the constructs (Ahmed et al., 2022). Therefore, it is recommended that the researchers establish cause and effect between the variables; they must use some additional models, including Toda and Yamamoto (1995).

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