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Hradec Economic Days

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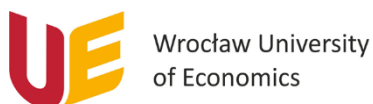
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Preface

Ladies and gentlemen, dear colleagues,

the Hradec Economic Days (HED) conference has been traditionally and continuously held since 2003. This year we are opening a new decade with our 22nd HED which took place April 11–12 in Hradec Králové. The University of Hradec Králové organized the conference in cooperation with the Wrocław University of Economics, the Cracow University of Economics.

The aim of the HED 2024 conference was to present the results of scientific research activities in the fields of economics, business economics, and management. We became a regular platform for meeting experts from such disciplines strengthening interdisciplinary relations and establishing personal contacts important for the submission of joint research projects and creating space for the presentation and publication of young members of an academic community. To fulfill these goals, we provided presentation sessions and a plenary session with foremostly keynote speakers:

- Alan Gibbons (Ambassador of Ireland to the Czech Republic),
- Magnus Svendsen & Jørgen Sjåvik (Founders of Oslo Analytic),
- Josef Diblík (External CFO and Consultant).

To boost academia and practice interconnection, we also prepared discussion sessions:

- Entrepreneurial Mindset & Team Building,
- Shareholder value and value creation.

Proceedings from the conference HED 2024 contain 45 contributions in English. The authors of the conference papers were academics and other professionals from the Czech Republic, Poland, China, Slovakia and Spain. I would like to warmly thank all participants of the HED conference for their contributions and favor. The final recognition belongs to the HED secretary assoc. prof. Ivan Soukal, editor Dr. Jan Mačí, our organization, and scientific committee for their work. I would like to thank our co-funding our partners: the project no. EHP-BFNU-OVNKM-4-214-01-2022 of the EEA Funds 2014-2021 and the grant no. 24RGI02-0077 of the Hradec Králové region.

Hradec Kralove, April 10, 2024   --

Assoc. Prof. Petra Marešová
General Chairman of Hradec Economic Days
Faculty of Informatics and Management
University of Hradec Kralove

CONTENT

Assessing Socio-Demographic Influences on Perceptions of the Benefits of Short-Term Rentals in the Sharing Economy: A Pilot Study

Karel ALLOH, Michal ČERMÁK, Petra ŠÁNOVÁ* and Josef ABRHÁM

Czech University of Life Sciences Prague, Prague, Czech Republic; Alloh@pef.czu.cz, Cermak@pef.czu.cz, Abrhamj@pef.czu.cz

* Corresponding author: Sanova@pef.czu.cz

Abstract: The sharing economy, especially in the tourism sector, is rapidly developing, changing traditional business models and bringing economic opportunities. However, its global spread reveals both advantages and disadvantages. While it promotes economic development and reduces consumer confidence, it is associated with the problem of over-tourism and generates negative sentiments in local communities. This paper examines the impact of the sharing economy on the tourism industry and highlights its role against the backdrop of the socio-demographic characteristics of customers. The sharing economy, which is challenging established businesses, requires a closer examination of its social and environmental implications. We use logistic regression analysis to test our hypotheses. Gender and age play a vital role in the perception of some of the benefits of short-term rentals in the sharing economy, particularly from a female perspective. This reflects the complex dynamics of social and cultural factors that influence how individuals perceive and use the services under study.

Keywords: collaborative efforts; future trends; sharing economy; socio-demographic factors; short-stay accommodation

JEL Classification: L83; Q56

1. Introduction

In the era of globalization and increasing integration of the world economy, the importance of information technology in shaping international economic relations is growing. Changes in social values drive the growth of the sharing economy, improved financial opportunities, and technological advances in online platforms, which facilitate the interconnection of users sharing and using previously untapped resources. The Committee of the Regions (Allen, 2014) recognizes the prevalence of sharing practices in the tourism sector and stresses the need to prioritize this sector.

The World Travel and Tourism Council (WTTC) (Basile & Caputo, 2017) highlights the economic impact and stresses that the sharing economy contributes significantly to the development of the tourism sector and accounts for 10.3% of the global gross domestic product (GDP).

The evolving economic environment, coupled with the increased emphasis on the sharing economy, is forcing organizations to analyze not only the needs of customers but also consider how to derive value from providing new products and services more sustainably (Peng et al., 2008; Wright et al., 2005).

The imperative of the concept of sharing forces organizations to design innovative solutions that anticipate future challenges. In addition to environmental aspects, the sharing economy brings aspirations and concerns related to economic and social dimensions (Demailly & Novel, 2014). These concerns are closely related to sustainable development and offer an alternative approach to understanding and rebalancing the economic, social, and environmental aspects. The overarching themes of the sharing economy and sustainable development represent a new research avenue for exploring sustainability issues within the sharing economy.

Airbnb in accommodation, Uber and Lyft in transportation, and Funding Circle, LendingClub, TransferWise, and Prosper in finance are examples of the sharing economy disrupting traditional capitalist enterprises in hospitality, mobility, and banking. Described as the primary infrastructure of the sharing economy (Mair & Reischauer, 2017), online platforms have been instrumental in its rapid expansion across industries, facilitated by the widespread use of smartphones and new mobile apps. Key characteristics of the sharing economy include non-transfer of ownership, temporary access, and redistribution of tangible goods and intangible assets (Kathan et al., 2016).

1.1. An Overview of the Sharing Economy and the Growth of Short-term Rentals

Different authors define the sharing economy, contributing to a diverse and multifaceted understanding of this conceptual framework Botsman and Rogers (2011) provided a new interpretation of the sharing economy, defining it as a systematic approach that leverages untapped resources through existing online platforms and market models, thereby increasing overall efficiency (Bernardi, 2018). In addition, Botsman and Rogers (2011) highlighted the development of online interactions that go beyond mere transactions and emphasized the development of interconnected communities. The term "sharing economy" officially appeared in the Oxford Dictionary in 2015 and is defined as "an economic system in which assets or services are shared between private individuals, involving both free and paid exchange, usually mediated through the Internet (Heo, 2016).

Sharing goods and services between different organizations and customers is increasingly important in today's economic environment. The term "sharing economy" encompasses a growing range of business models, platforms, and exchanges, as Allen and Berg (2014) note.

The emergence of the sharing economy in the tourism industry is linked to the global financial crisis (2008-2009). Gansky (2010) noted that changes in consumer behavior often coincide with economic downturns, characterized by a propensity to experiment with new brands and an increased emphasis on value for money. As a result, the economic recession, characterized by reduced purchasing power and the desire to save and generate additional funds, has provided a favorable environment for establishing sharing economy

models in the tourism sector. As Dominici et al. (2018) noted, the first manifestations of the sharing economy were evident in tourism services, specifically in car rental and housing. This introduction provided tourists with a broader range of alternatives, allowing them to choose the most optimal solution to suit their needs and financial considerations.

A new and rapidly developing phenomenon that significantly impacts tourism development is the sharing economy. Compared to other tourist destinations, cities are mainly characterized by the rapid growth of the sharing economy, characterized by the emergence of major global businesses such as Uber, Airbnb, and Couchsurfing. These platforms play a vital role in the provision of tourism services for shared consumption, as highlighted by the research of Varsanis et al. (2019). The spread of the sharing economy in tourism services is particularly evident in major world cities such as New York, Berlin, Barcelona, or Paris. Extensive research shows that this phenomenon has significantly impacted urban tourism, encouraged increased inbound tourism, and introduced a new dimension of competition in the tourism sector. It is worth noting that the effects of the development of the sharing economy go beyond the tourism sector, as shown by the research conducted by Moreno-Izquierdo et al. (2019).

As stated by Marr (2016), a notable trend for the future is the reduction of ownership and an increased willingness to engage in sharing. The importance of ownership is expected to decrease, and there will be a significant shift towards emphasizing the potential inherent in collaborative sharing. However, within tourism, as Heo (2016) points out, the sharing economy introduces a transformative concept that blurs the traditional distinctions between consumers and service providers and between locals and destination businesses. This transformational shift has profound impacts, particularly in accommodation supply, with wide-ranging implications for integrating real estate into online platforms and facilitating shared use among different stakeholders.

As argued by Moreno-Gil and Coca-Stefaniak (2020), the sharing economy affects various aspects of tourism supply, including accommodation, transport, catering, guides, and others. Moreover, Goodwin (2017) explicitly highlights the role of the sharing economy, particularly platforms such as Airbnb, as a significant contributor to destination overtourism. Significantly, he highlights the substantial and adverse consequences, pointing to problems within the housing market that drive up rents and displace lower-income earners, thereby disrupting residential neighborhoods.

Extensive research has looked at the integration of the sharing economy (CE) into the tourism sector, with a particular focus on accommodation and transport, as evidenced by studies such as those conducted by Guttentag et al. (2018) and Zervas et al. (2017). It is noteworthy that emerging scholarship is beginning to explore the implications of the sharing economy in the field of dining experiences, as evidenced by recent studies, including the work of Ketter (2019), contributing to a more comprehensive understanding of the impact of the sharing economy in different aspects of the tourism sector.

1.2. Socio-Demographic Knowledge

The impending dominance of millennials in the workplace is poised to significantly impact the trajectory of organizations while simultaneously strengthening their purchasing power. In the context of travel, the report "The Travel Gold Rush 2020" (Chérèque, 2020) highlights millennials' strong spending habits on international travel, which is expected to reach a staggering $340 billion by 2020. This financial commitment underscores their deep interest in travel, surpassing even the Baby Boomer generation. Notably, millennials tend to travel abroad more frequently than their predecessors, as evidenced by studies such as Expedia Media Solution's European Multi-Generational Travel Trends 2017.

The link between millennials and tourism is of growing interest in the scientific community, as evidenced by studies such as those conducted by Benckendorff et al. (2010) and Ruspini and Bernardi (2018). This highlights the crucial need to adopt a generational perspective for a more nuanced understanding of tourism's future supply and demand dynamics. Such an approach is essential to capture emerging trends and effectively steer the tourism market.

Environmental factors within the sharing economy depend on conditions unique to each business model. First, environmental sustainability in the sharing economy focuses on maintaining the stability of biological and physical systems. Second, it involves reducing the production of goods to promote sustainable consumption patterns. As Demailly and Novel (2014) point out, the quality of shared goods is critical to the environmental sustainability of various sharing business models, including redistribution, mutualization, peer-to-peer systems, and shared mobility.

2. Methodology

Our research efforts traditionally involve the collection of our data. In this case, however, the importance lies in the availability of relevant data from European Union (EU) countries. Given the unique nature of this circumstance, we decided to take advantage of an existing, carefully conducted survey and use it as the basis for our analysis. This strategic decision is underpinned by recognizing the intrinsic value and reliability associated with data obtained directly from EU Member States. This approach increases the efficiency of our research process. It underlines the credibility and reliability of the information available, which aligns with our commitment to careful and informed scientific inquiry.

Data from the Eurobarometer 495 flash survey was collected in September 2021 to validate our conceptual model and test our hypotheses. The survey was conducted via telephone interviews. The target group was EU citizens aged 15+, and the survey covered 27 EU countries. The sampling methodology includes a dual frame, fixed line, and mobile phone and is a probability model. The number of interviews was 25,297. The sample size in each country was 1000. Only Luxembourg, Cyprus, and Malta had a sample size of 500. Ipsos European Public Affairs carried out the fieldwork. The investigation of these phenomena is carried out in a comprehensive sample encompassing 27 European Union countries. The sample comprises 25,297 individuals with an average age (M±SD) of 47.62±16.81, ranging from 18 to 100 years. The gender distribution is balanced, with 12,713 males (49.50%) and

12,844 females (50%). Statistical software SPSS (Statistical Package for the Social Sciences) was used to analyze and calculate the results.

2.1. The Question and Answers

Q7. *What are, in your view, the advantages of short-term rentals offered via collaborative economy platforms?*

- Travelling is more affordable.
- Additional source of income for hosts.
- Visitors spend more money in the neighborhoods where they stay.
- Visitors stay in less-touristed neighborhoods.
- Leads to more local investment.
- Improvement in public services.
- Improvement in local amenities.

2.2. The Model

We apply logistic regression analysis to test the hypotheses:

$$Benefits= Logit\ (a0+ a31\text{-}31\ Age + a32\ Gender + e) \tag{1}$$

2.3. The Hypothesis

- H1: *Younger individuals perceive the advantage of short stays in the sharing economy more than older individuals.*
- H2: *There is an assumed difference in the perceived advantage of short-term rentals in the sharing economy between men and women.*

2.4. Age Distribution

As part of the methodology, the age of the respondents was categorized into specific age groups with respect to generational distribution. Specifically, the following age categories were created:

- *Generation Z*: Respondents aged 18-26 belong to this generation.
- *Group Y (Millennials)*: Respondents aged 27-42 were classified as Millennials, also known as Generation Y.
- *Group X:* Respondents aged 43-58 were classified as Generation X.
- *Group BB (Baby Boomers):* Respondents aged 59-77 were categorized as members of the Baby Boomer generation.
- *Group SG (Silent Generation):* Respondents aged 78 and over were categorized as Silent Generation.

This categorization of age groups allows for a systematic and comparable view of respondents' responses across generations, which helps to provide a deeper understanding of patterns and trends in the data set.

Notes: Generation Alpha participants are not included in this study. We only include participants over 18 in the study, allowing us to create a more transparent and practical structure for subsequent

analyses. Segmentation of respondents by age based on generations is implemented to make our data analysis and interpretation process more accessible and straightforward.

3. Results

The overall distribution of how respondents chose can be found in Figure 1. This figure contains the graphical results of the responses to question Q7.

This visual representation is a tool for analysts and the broader public interested in tracking and understanding the issue at hand, the benefits of short-term shared accommodation rentals. Source of figures 1, 2 and 3 is own processing using Eurobarometer data.
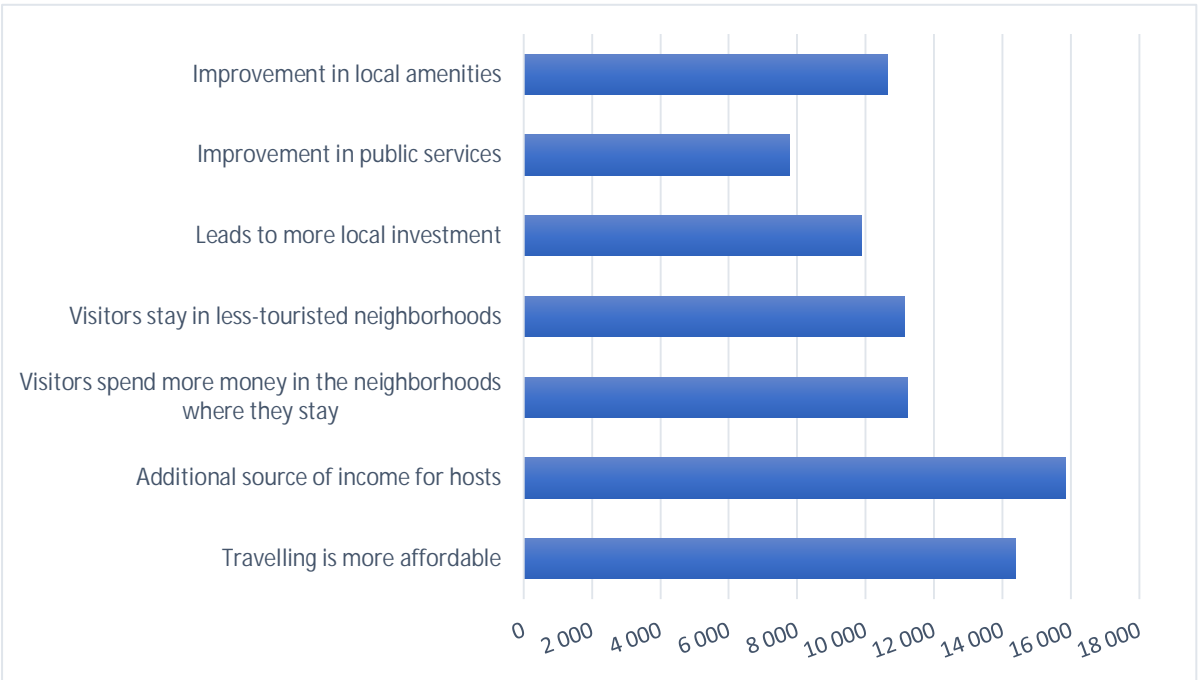
Figure 1. The overall distribution of respondents' answers

Our analysis generated results that are systematically presented in Table 1. These results are supplemented with verbal comments for better clarity and more detailed interpretation. Within these comments, individual table entries are identified by their respective letters, the detailed explanation and context of which are provided in the notes to Table 1. This approach will ensure that readers have a clear picture of the expert results and can better understand the interpretation of the individual items presented in the table. Source of table 1 is own processing using Eurobarometer data.

The regression analysis conducted found that factors such as age and gender have a significant impact on the way the benefits of short-term shared accommodation are perceived. Age and gender were critical determinants of individuals' preference patterns and attitudes towards this accommodation. These findings suggest that a personalized approach to target groups based on age and gender characteristics may be essential to successfully reaching and persuading potential users of short-term shared accommodation.

The analysis of the effect of age on the perceived benefits of short-term rentals showed significant variability in all aspects examined. These findings suggest that individuals of

different ages approach these benefits with different regard and evaluation. Figure 2 shows individual responses by age.

Table 1. Results of regression analysis for Socio-demographic characteristics

	A		B		C		D		E		F		G	
	Est.	Sig	Est.	Sig	Est.	Sig	Est.	Sig	Est.	Sig	Est.	Sig	Est.	Sig
Threshold=1	0.24	0.456	-0.511	0.122	0.704*	0.031	0.652*	0.045	-0.194	0.56	0.131	0.706	-0.083	0.804
Socio-demographic characteristics														
Age	-0.008***		<.001		-0.008***		<.001		-0.009***		<.001			
Gender	-0.12***		<.001		-0.071*		0.018		-0.062*		0.025			
Age	-		-		-		-		-		-		-	
Gender	-		-		-		-		-		-		-	

Notes: Link function: Logit. gender – women *** - significant on 0.1% level. ** - significant on 1% level, * - significant on 5% level. A = Travelling is more affordable; B = Additional source of income for hosts; C = Visitors spend more money in the neighborhoods where they stay; D = Visitors stay in less-touristed neighborhoods; E = Leads to more local investment; F = improvement in public services; G = Improvement in local amenities. + denotes positive statistically significant association on conventional levels, - denotes negative statistically significant association on conventional levels.
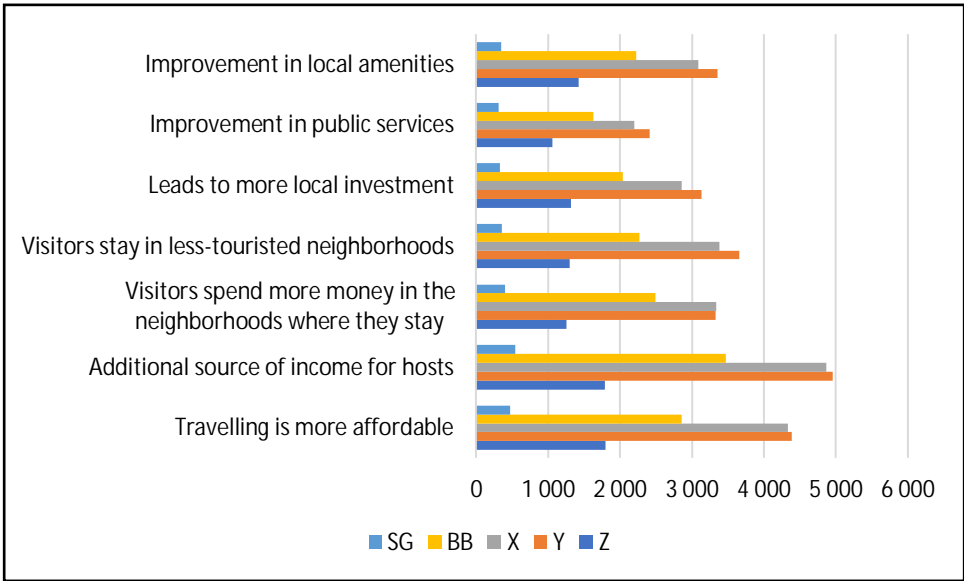
Figure 2. Distribution of respondents' answers by age

The analysis of the effect of age on the perceived benefits of short-term rentals showed significant variability in all aspects examined. These findings suggest that individuals of different ages approach these benefits with different regard and evaluation. Figure 2 shows individual responses by age.

In the analysis of differences in perceptions of the benefits of short-term rentals in the sharing economy, several vital variables were found to be statistically significant. Of note is the perspective of women, who experience a significant advantage in travel affordability. Another significant dimension for women is the observation that visitors spend more money in the neighborhoods where they stay. Another critical dimension is the perception that

visitors prefer to stay in less frequented neighborhoods. The last significant benefit identified is the improvement in public services. Figure 3 shows individual responses by gender.
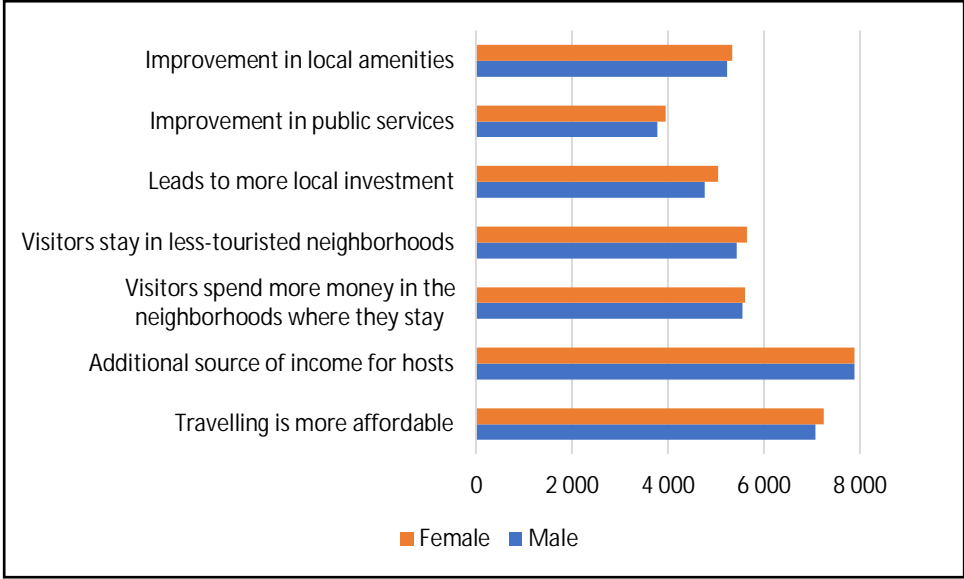
Figure 3. Distribution of respondents' answers by gender

4. Discussion

Our recent regression analysis has provided exciting perspectives on the factors influencing perceptions of the benefits of short-term shared accommodation rentals. The results clearly show that age and gender play a crucial role in how individuals perceive this form of accommodation, and it is fascinating to see how different age and gender groups respond to the concept of short-term shared accommodation. These findings invite us to discuss and explore these dynamics more deeply.

As part of our analysis of perceptions of age-based benefits, we identify several variables that influence this perspective. In our research, we observed statistically significant results about age groups. However, it is essential to investigate the factors that explain the tendency of younger individuals to use sharing economy accommodation services more frequently than older clientele.

According to a report by Travel Technology & Solution (TTS) (2015), the 21 to 34 age group, known as millennials, make up the highest percentage of sharing economy users. Some of them prefer the specific nature of this type of travel. Conversely, the traditional hotel with its city vehicle or hired transport remains the preferred choice for business travellers.

Even though sharing economy accommodation offers more affordable alternatives than traditional hotels, there are serious concerns about the uncertainty of room size, building quality, and overall cleanliness. This uncertainty becomes more critical, mainly when focusing on the possibilities of dealing with unexpected problems during the stay.

A study by Knutson et al. (2009) identified four factors affecting the hotel experience: benefit, convenience, motivation, and environment. Thus, travel motivation can variably affect everyone. Some studies (Griswold, 2016; Ting, 2017) even view sharing economy accommodation platforms, such as Airbnb, threatening traditional hotels. On the contrary,

the main goal of sharing economy platforms, according to Tussyadiah and Pesonen (2016), is to enable people to experience destinations as local.

Only a few studies have addressed the dimensions and variables influencing customer intentions in the sharing economy (Amaro et al., 2018; Camilleri & Neuhofer, 2017). Amaro et al. (2018) conducted empirical research focusing on the booking intentions of millennials through Airbnb. Their results showed that subjective norms, economic benefits, and attitudes are critical to booking intentions. Millennials prefer authenticity, value for money, flexibility, and experience over traditional forms of accommodation.

As a rule, sharing economy services are booked online, often via smartphones. However, some age groups may still need to gain more knowledge and experience with these applications, confirming the importance of awareness of online platforms, according to Guttentag (2015).

Guttentag (2015) analyzed Airbnb from a disruptive innovation theory perspective and suggested that despite Airbnb's lower performance on primary attributes such as service quality and safety compared to traditional hotels, it offers an alternative value proposition. This alternative focuses on cost savings and has the potential to provide a more authentic experience.

The concept of authenticity has been studied for a long time, and it appears that this factor is critical regarding gender and age. For example, one of the benefits of authenticity is that visitors stay in less visited neighborhoods. Sharpley (1994) has previously explored the concept of authenticity in tourism and hospitality, defining *authenticity* as a sense of uniqueness based on local culture. Lyu et al. (2018) add that the sharing economy of accommodation allows for interaction between customers, which can lead to unique experiences.

Within the sharing economy, some researchers, such as Birinci et al. (2018) and Lyu et al. (2018), highlight the importance of authenticity as a critical dimension, especially in the context of Airbnb and customer experience. Of note is the perspective of women who perceive more significant benefits in travel affordability. This perspective is likely related to their perception of short-term rentals as an option to reduce accommodation costs while traveling.

Research conducted by Guttentag et al. (2018) interviewing over 800 Airbnb users in Canada and the US confirmed that customers are primarily attracted to the practical benefits of the platform, such as price, location, home amenities, social interaction, authenticity, and novelty. These findings are consistent with European socio-demographic research, where age and gender influence price benefits, location, and authenticity perceptions. The question of why women perceive more significant advantages in these variables remains open and would merit further research. An analysis of 50 million hotel reviews conducted by Wit (2014) showed differences in ratings between demographic groups, with women emphasizing atmosphere and friendly surroundings, while men emphasize professional service and hotel facilities. This suggests that ambiance and friendly environment may be critical attributes preferred by women who stay in accommodation through the sharing economy (Airbnb). At the same time, men may be more interested in professionalism and hotel facilities.

5. Conclusions

Differences in perceptions of the benefits of short-term rentals in the sharing economy are the complex result of a multifactorial web of influences reflecting individual characteristics associated with age. Different life stages, priorities, and experiences can significantly influence the assessment of the benefits of short-term rentals. For example, younger generations may value flexibility and quick accessibility, while older individuals or families place more emphasis on stability.

Differentiation in perceptions is not limited to age; it combines individual preferences, life circumstances, and changing values. This dynamic creates a rich area for further research that will provide deeper insight into the role of age and related factors in perceptions of short-term rentals in the sharing economy.

Similarly, differences in perceptions of the benefits of short-term rentals are not limited to age but also include a gender dimension. Sociocultural norms may influence how men and women approach sharing accommodation options. For example, women may emphasize safety and comfort, while men emphasize practicality and accessibility. These different perspectives raise questions about adjusting short-term rental offerings and marketing strategies better to reflect the needs and preferences of different groups. Further research may provide valuable insights into gender-specific trends and expectations in the sharing economy.

Conflict of interest: none.

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Talent Management: Insights into Recruitment in the SME Environment

Matthias BENDER* and Lubica BAJZIKOVA

Comenius University, Bratislava, Slovakia; bender2@uniba.sk, lubica.bajzikova@fm.uniba.sk

* Corresponding author: bender2@uniba.sk

Abstract: Demographic change is a development that is increasingly presenting companies with challenges. The German brewing industry's workforce is largely made up of older, well qualified employees who are likely to leave the labor market in the coming years. The brewing industry is also facing falling sales figures. Most breweries can be classified as small and medium sized enterprises (SMEs). Against this backdrop, the question arises as to whether the German brewing industry is still attractive enough to gain enough young talent and how they are currently being recruited. To determine this, both future employees (target audience 1) and employer representatives (target audience 2) were interviewed. As comparable studies with numerical data were available for target audience 1, a quantitative research approach was pursued here. As this does not apply to target audience 2, a qualitative approach was pursued for this group. The aim of this article is to gain an insight into how recruitment is implemented in brewery industry and how this process could be improved. The methods of recruitment for future employees are still very traditional (job advertisements and network). No evidence of employers using headhunters or active search strategies could currently be found in this industry. Nevertheless, every brewery should continue to plan staff replacement with care, as the upcoming generational change could make it more difficult to recruit new employees.

Keywords: talent management; small and medium-sized enterprises (SME); recruitment; brewing industry

JEL Classification: J10; M12; M51

1. Introduction

The current framework conditions create a new situation at the labor market for graduates, employees and employers. One of the key factors in this context is the demographic change (Trost, 2012, p. 8). On the one hand, more and more older employees are leaving the labor market and, on the other, there are no longer enough young graduates available to replace these retirements. To counteract this development, the implementation of a talent management process (Chambers et al., 1998, p. 46) is recommended to *"attract, retain, develop, and motivate highly skilled employees and managers"* (Noe et al., 2022, p. 13).

All enterprises are affected by this development, regardless of their size. As small and medium-sized enterprises (SMEs) generally have fewer resources (Olbert-Bock et al., 2015, p. 1; North, 2016, p. 192), for this reason they must take a more efficient approach. However, this can only be achieved if the necessary basis for decision-making is available. Even though

Chambers et al. (1998) emphasize that companies must *"develop, develop, develop"* their employees, the personnel must be recruited as well (Chambers et al., 1998, p. 46). In general, the topic of talent management is dealt with particularly in the US/Anglo-Saxon and Chinese regions (Ewerlin, 2013, p. 8; Bostjancic et al., 2018, p. 2). Elsewhere, it is noted that talent management is well researched in many parts of the world, but that there is still a need for research in individual national industries (Amushila et al., 2021, p. 2). Jibril and Yeşiltaş (2022) note in their article that the literature focuses on the aspects *"acquiring, developing and retaining talent"* (Jibril & Yeşiltaş, 2022, p. 3). Savov et al. (2020) highlight in their article the difficulty of recruiting the talented staff that will add more value to the company (Savov et al., 2020, p. 6). It has also been found that the size of the company has an influence on the implementation of talent management (Savov et al., 2020, p. 1).

Maack et al. (2011) has found that the German brewing industry is nowadays facing economic challenges on the one hand and has an older workforce compared to the food industry on the other one (Maack et al., 2011, p. 7). This situation as described before, and the increasing effects of demographic change could tackle the German brewing industry with a personnel management challenge.

The above-described conditions create following research questions:

- Is the German brewing industry affected by a shortage of young professionals?
- How is recruitment implemented in small and medium-sized breweries?

To answer this research questions, the following aspects will be elaborated in the further analysis:

- What are SMEs? (1)
- Is the German brewing industry an attractive area to work in? (2)
- What is meant by recruitment and are there measures that are particularly related to the talent management process? (3)
- What is the view of potential employees? (4)
- What is the employer's perspective? (5)

Questions (1) to (3) were analyzed with the help of an exploratory review. As comparable studies were available, question (4) was analyzed by using a quantitative research approach. As this was not apply to question (5), a qualitative research approach was used. The aim of this article is to gain an insight into how recruitment is implemented in brewery industry and how this process could be improved.

2. Methodology

The methods – exploratory review, quantitative and qualitative research – used in this article are presented in detail below.

2.1. Exploratory Review

The purpose of the exploratory review is to determine what knowledge is available on a particular topic. It is important to concentrate on the respective research focus (Adams et al.,

2007, p. 56). *"The review should be seen as being informative to the researcher and providing him/her with clearer ideas on the common theories [...]."* (Adams et al., 2007, p. 57)

Here, it is particularly important to determine how SMEs can be differentiated and how they are distributed in terms of volume according to size categories. To continue working on the topic, it is also necessary to determine what advantages the brewing industry could offer. Finally, it is necessary to work out how recruitment differs from the perspective of Human Resource management (HRM) and talent management.

2.2. Quantitative Research: Target Audience 1 – Employees

A quantitative research approach is characterized by standardized data collection, which is based on the approach of the natural sciences. Numerical data is required for this (Kuckartz, 2014, p. 28).

Comparable quantitative research results are available for target audience 1. A quantitative research approach was therefore developed. As this target audience must have a clearly defined background, a cluster sample was prepared at two geographically dispersed training institutions. A questionnaire was developed for data collection and made available to the participants digitally via the platform "soscisurvey.de". The data received was processed descriptively using Excel. The mode and the mean value were important parameters in the study.

2.3. Qualitative Research: Target Audience 2 – Employer Side

The qualitative research approach draws on non-numerical data. This approach is better suited to capturing the perspective of the research participants (Kuckartz, 2014, p. 28).

Target audience 2 consists of employer representatives from the SME environment. Comparable analyses were not available for this group. A qualitative research approach was therefore developed. The intention was to gain one interview partner for a microbrewery, one for a small brewery, and one for a medium-sized brewery. The snowball sample was used because the search for participants proved extremely difficult. Data was collected with the help of an interview guide. The interviews were then subjected to a qualitative content analysis. The MaxQDA computer program was used for this purpose. The necessary codes and subcodes were developed inductively and deductively.

3. Results

The results are presented in the order specified in chapter 2. Chapter 3.1 and 3.2 summarizes the theoretical background. The results of target group 1 (employees) are summarized in chapter 3.3 and the results of target group 2 in chapter 3.4.

3.1. Theoretical Background – SMEs and Background Brewing Industry

The threshold values for company sizes were defined by the EU in January 2005. The criteria are the number of employees and the turnover or balance sheet total. If a company has less than 250 employees and a maximum turnover of EUR 50 million or a maximum balance sheet total of EUR 43 million, then it is a SME. The employee thresholds are relevant

for further processing. According to these specifications, a microenterprise has a maximum of 9 employees, a small enterprise a maximum of 49 employees and a medium-sized enterprise 249 employees (IfM, 2024).

According to STATISTA (2024), there were a total of 3,435,478 companies in Germany in 2022. The distribution by size class can be seen in Table 1 (STATISTA, 2024).

Table 1. Distribution of German enterprises by size category (STATISTA, 2024)

Size	Number	Percentage
Micro	2,982,478	86.8%
Small	361,638	10.5%
Medium	74,398	2.2%
Large	17,045	0.5%
Total	*3,435,478*	*100%*

In 2022, there were 1,507 breweries in Germany. Based on the statistical data 1,355 breweries were SMEs with a maximum production of 50,000 hectoliters (hl) for one enterprise each year (DBB, 2024a). Overall, it can be stated that the brewing industry is facing a challenge. Two long-term trends can be observed – a decrease in beer consumption and an increase in the consumption of non-alcoholic beverages (Stracke et al., 2017, p.19). Annual consumption of beer per person was 91.8 liters in 2022. Compared with 2004, this number was still 116 liters (DBB, 2024b). In contrast to this development, the number of breweries increased from 1,359 to 1,507 enterprises between 2014 and 2022 (DBB, 2024c), whereby the growth is mainly driven by smaller breweries (DBB, 2024a). From an HR perspective, it is observed that the workforce has become older (see Table 2).

Table 2. Age distribution in the brewing industry, comparison 2007 and 2016 (Stracke et al., 2017, p. 98)

Year	Age under 25	Age 25–49	Age 50–64
2007	9%	63%	28%
2016	9%	51%	40%

Looking at the level of qualification, the following data emerges (see Table 3).

Table 3. Distribution of qualification levels, comparison 2007 and 2016 (Stracke et al., 2017, p. 102)

Year	2007	2016
No professional qualification	13%	10%
recognized professional qualification	78%	76%
Academic professional qualification	7%	9%
not specified	2%	5%

In terms of remuneration, it can be stated that the average gross wage in the brewing industry was higher compared to the beverage industry. Brewers were able to earn an average per year of 3,500 EUR more in 2015 (Stracke et al., 2017, p. 148f).

Remarks: Both in the distribution of all enterprises in Germany and in the distribution of German breweries by size, a majority can be assigned to SMEs. It therefore makes sense to gain further insights specifically for this environment. Due to the high number of older employees, it could be difficult to replace them with suitable personnel in the future. Based on the level of qualifications identified, it can be concluded that the brewing industry is a

working environment with a high-level qualification requirement. Whether this is an advantage or disadvantage for the future cannot be assessed right now. The fact that the brewing industry has had the opportunity to pay higher wages is certainly an advantage if this can be maintained.

Based on the results so far, it can be assumed that recruiting staff can be a challenge for the brewing industry. It is therefore particularly important to determine how and when it is best to find young talent.

3.2. Theoretical Background – Talent Management and Recruitment

First it should be clarified what HR management and talent management are. HR management is the *"sum of all HR design fields and individual measures to support current and future corporate development (business development) and the associated change processes (organizational development)"* (Bartscher & Nissen, 2018). Talent management are *"internally and externally directed strategies, methods and measures with which a company ensures that the key positions critical to business success are filled with the right employees: goal-oriented action to discover, recruit, develop, promote, optimally place and retain talent in the company"* (Hattburg, 2018). What is the relationship between HR management and talent management? Noe et al. (2022) have created an overview in which functions and responsibilities are linked. In this overview, it is stated that talent management is responsible for supporting the defined strategy in the HR department. Recruitment is seen as an independent function (Noe et al., 2022, p. 7). At the same time, however, recruitment is part of the talent management process (Noe et al., 2022, p. 13). *"Like most 'young' concepts in science, there has been disagreement amongst academics as to what actually constitutes talent management"* (Carbery & Cross, 2019, p. 27). One question is whether every employee in a company a talent or only individual employees are. If all employees are seen as talent, this is referred to as an inclusive approach. Exclusive, if only selected ones are considered (Carbery & Cross, 2019, p. 27). Personnel can be recruited both inside and outside the company. There are various measures that can be used for external recruitment for this purpose. Corresponding measures are also proposed in the literature for talent management. For the sake of clarity, these have been summarized in Table 4.

Table 4. Overview of personnel recruitment measures (Carbery & Cross, 2019, p.42 f; Noe et al., 2022, p. 149; Trost, 2012, p. 82 ff)

Carbery and Cross (HR)	Noe et al. (HR)	Trost (TM)
Recruitment Consultancies	Employee referral	Social Community Recruiting
Employee Referrals	Recruiters	Employee Referrals
Graduate Recruitment	Employment agency	Campus Recruiting
E-Recruitment	Campus recruiting	Talent Scouting
International Recruitment	E-Recruitment	Competitive Intelligence
		Guerilla Recruiting

Remarks: While HR management can be clearly assigned to an organizational unit, this is not readily possible for talent management. Kahl (2011) states that roles and responsibilities must be clarified in this context. In addition to the HR department, executives and top

management must also be involved (Kahl, 2011, p. 25). As SMEs generally have fewer hierarchical levels (Trost, 2014, p. 260), the need for coordination is likely to be lower. As the loss of one employee in a 5-man company is likely to have a major impact, SMEs should adopt a more inclusive approach.

The upcoming study must determine what is expected of future employees and what their aims are. These results must be checked by the employee side for their feasibility and whether this is already implemented or not. As inclusive talent management is the more suitable approach for SMEs in particular, all employees should be considered and challenged and promoted according to the needs of the company and their respective skills. Due to the lower hierarchies in SMEs and the similar perceptions that can therefore be assumed between owners and employed managers, no further differentiation is considered necessary here either.

3.3. Results Target Audience 1 – Employees

A total of 95 male (78) and female (17) students participated in the study in fall 2022. The data collection was carried out at two German training institutions. Due to the orientation, one training institution stipulated that a vocational qualification was required. The participants in survey were between 18 and 39 years old, with an average age of 24.89 years. Around 73% of participants have a higher education entrance qualification or an entrance qualification for universities of applied sciences, and 6% already have a university degree. Prior exposure to the brewing industry through personal connections is distributed as follows (see Table 5).

Table 5. Summary of the family background on the brewing industry

Family background brewing industry	Number
none	79
Family hobby	2
Family part time job	1
Family full time job	7
owner brewery	6

The questions on vocational orientation were only asked of those participants for whom this was a mandatory requirement for admission to the respective training institution. The following table shows the age at which the participants began their career orientation and when they decided to join the brewing industry (see Table 6).

Table 6. Age range of professional orientation and decision-making

Start of professional orientation														
Number	4	4	9	4	7	2	9	1	1	1	1	3	1	
Age	14	15	16	17	18	19	20	21	23	25	26	28	31	
Decision for the brewing industry														
Number	1	5	2	6	9	7	2	3	1	2	2	1	1	2	2
Age	14	15	16	17	18	19	20	21	22	23	25	26	28	29	32

Based on the survey data the following recruiting methods are common: 54.35% of participants became aware of their future employer through a job advertisement and 43.48% through friends and family. Professional intermediaries did not play a role in this context.

All participants were again asked about the channels through which they obtained information about their future. They were also asked which channels were rated as particularly useful (see Table 7).

Table 7. Overview of used and useful information channels

Channel	Number used	Number useful	Channel	Number used	Number useful
Printed Media	13	6	School Event	27	9
Employment agency	7	4	Teacher	15	13
Career Fair	20	11	Internet	81	52
Internship	51	42	Friends	52	38
Social Media	25	10	Parents	42	22

The survey participants could work in different industries due to the degrees they are aiming for. When asked about their preferences, the following overview emerges (see Table 8).

Table 8. Overview of industries and preferences

Industry	Number	Industry	Number	Industry	Number
Brewing	79	Biotechnology	11	Systems Engineering	25
Beverage	58	Environmental	8	Public Employer	13
Food	18				

According to the questions about the preferred enterprises size and preferred place of work, the following results emerges (see Table 9).

Table 9. Overview of preferred company sizes and work locations

Company size	Number	Work location	Number
Micro	4	Home region	60
Small	41	Germany	35
Medium	34	inside EU	30
Large	16	outside EU	21

Participants were also asked about their career aims they were pursuing and how often they expected to change employer during their working life. The results are summarized in Table 10.

Table 10. Overview of career aims and expected number of employers

Professional aim	Number	Number of employers	Number
takeover brewery	3	up to 3	33
independent entrepreneur	18	up to 6	46
employed manager	48	up to 9	11
skilled worker	8	10 and more	2

Finally, the surveyed participants were asked to make comments about their expectations. For this information it was used a 5-point Likert scale, where 5 stands for "strong acceptance". The following table shows the five fields of research with the corresponding mean values and the most important individual expectations in each case (see Table 11).

Table 11. Summary of the expectations expressed

Expectations	Work Live Balance	Development	Financial Aspects	Working Environment	Employer Brand
Mean value	3.8	4.3	3.7	3.9	2.8
Important aspects	Work must be fun	Further training, Feedback, Appreciation of performance	Good basic salary	work is not only a job, Teamwork, familiar working atmosphere	Positive employer image

Remarks: Based on the data obtained, it can be concluded that the brewing industry is an attractive working environment despite of mentioned problems. 87.6% of the survey participants decided to work for this brewing industry without having experienced a family background beforehand. The same proportion of survey participants can assume working in the brewing industry after graduation, especially in an SME environment. 63.2% could also prefer working in their home region. Around 54% stated that they had found their employer through a job advertisement and around 43% through family and friends. It seems that the respondents tend to be connected to their home region. The preferred information channels (internet, internship, friends, and parents) could also be described as down-to-earth. Many of them want to work in the SME sector. There are many SMEs on the labor market. The fight for talent could be less intense due to the respective closeness. The expectations expressed are generally realistic. From the companies' point of view, these are positive results for recruitment.

However, it becomes more difficult if no candidates are available or sufficiently qualified. Then it could be a challenge to find alternatives. Another problem could be the professional aims. 50.5% of surveyed participants want to become an employed manager. However, SMEs in particular only have a few hierarchical levels. The advantage for enterprises could be that they can select from several applicants/candidates for these vacancies. A challenge for recruitment could arise if the frequency of change of employer is as expected by the participants.

Before any further steps can be taken, the results of the investigation must be evaluated by the employer side in terms of their feasibility.

3.4. Results Target Audience 2 – Employer Side

One owner for a microbrewery A (1 employee) and one for a small brewery B (20 employees) took part in the interview on the employer side. For a medium-sized brewery C (70 employees), an employed manager participated. The sample was not about fulfilling abstract-methodological requirements, but about concrete-content statements (Flick, 2019, p. 163). The evaluation of the interviews revealed the following situation:

Only C has its own HR department. What they all have in common is that their HR work is of an administrative nature. Most employees are over 30 years old and come from the surrounding area. Only B also employs unskilled workers. The employees are usually working at the breweries for many years. Recruitment is carried out with the help of job advertisements and via the respective network. Active search strategies (see Table 4) are currently not used. However, unsolicited applications from employees are also common. Only C offers internship opportunities. Further training in connection with the respective task is obligatory. Only C enables cross-disciplinary training. From the employer's point of view, the employees' objectives and expectations are in most cases achievable. The preferred career aim as employed manager is seen as problematic, as these positions are limited due to the existing structures.

Remarks: Since, according to the assessment made here, most of the aims and expectations are realistic. It can be assumed that breweries are generally attractive employers. Otherwise, they would not receive any initiative applications. Further training is an important expectation set by the employees. It should be examined whether job-oriented further training will continue to be sufficient in the future. The regional focus of the employees was also confirmed by the employers. However, if one compares the comments on the length of service of active employees with the expectations of the study participants with regard to presumed changes of employer, a discrepancy emerges.

From a recruitment perspective, information about the possible increased willingness of future employees to change employers is essential. The labor market and training qualifications give study participants the opportunity to change employers. Therefore, recruitment and selection should be carried out carefully to avoid unnecessary changes. The employers surveyed tend to play a passive role in the recruitment process. The use of active search strategies would be an option if recruitment becomes more difficult on the timeline. To avoid direct conflicts with other breweries, campus recruiting should be used first.

4. Discussion

The McDonald Ausbildungsstudie is a good basis for comparing the obtained results. In summary, it can be said that the results in both studies are similar. This is exemplified by the results on expectations and the information channels used (see Table 12).

Table 12. Comparison of McDonald's Ausbildungsstudie 2019 (Köcher et al., 2019, p. 60 f and p. 82) with our study

Expectations		Channels	
McDonalds	current research	McDonalds	current research
1	Work must be fun	(1) Parents	(1) Internet
4	familiar working atmosphere	(2) Friends	(2) Friends
5	work is not only a job	(3) Internet	(3) Internship
7	Appreciation of performance	(4) Internship	(4) Parents
9	Further training		
15	Good basic salary		
23	Teamwork		
33	Positive employer image		
not specified	Feedback		

The most important expectations from the current study can be seen in Table 12. The expectations listed here are all particularly important for the study participants. The same expectations were also identified in the Ausbildungsstudie. However, the results differ in terms of value. It is therefore very important for both samples that the work is fun. However, the employer image is not as decisive as in the current study. One reason for the difference could be that the age structures are different. In the training study, 58% of the participants were students or trainees (Köcher et al., 2019, p. 106). In the current research, the participants were all young adults, some of whom had already been in employment. This could also be the reason why a good wage is more important in the current study. The most frequent channels for vocational orientation are similar in both studies. It is also understandable that the use of the internet is more important in the current research. Most respondents do not have parents who are working in the brewing industry. It therefore makes sense to use a different source for orientation. Fuchs (2020) found in her study that more than half of the participants expect to change employer between 6 and 10 times (Fuchs, 2020, p. 23). In the current study, the willingness to switch is less pronounced. 59 participants stressed only 4 to 6 employer changes.

To classify the employers, one comparative study was found which made statements on the respective institutionalization of HR management in the companies. Richter (2019) found that medium-sized companies have a human resources department (Richter, 2019, p. 26).

The value of this study is limited by the fact that only a limited number of persons participated on this survey. As the differences found are comprehensible, the findings obtained here form a good basis for drawing conclusions for personnel recruitment in the brewing industry.

5. Conclusions

Based on the findings obtained here, it can be stated for the surveyed breweries that recruiting staff is not yet a problem. It is interesting to note that employers are still successful with a rather passive and traditional approach to recruiting staff. Active search strategies are not currently being pursued. This would therefore be a starting point if recruitment becomes more difficult. Two of the three breweries are not currently training staff but are hiring professional personnel. Whether this is sustainable in the long term should be carefully monitored. If the framework is changing, the restructuring of recruiting must be changed very fast. As a big number of old employees will be leaving the labor market in the next few years, and it is currently unclear whether recruitment will be able to compensate these retirements, technical alternatives should also be prepared. A downsizing strategy could also be introduced, or employees could be made co-owners if it is foreseeable that the vacant positions cannot be replaced by new hires.

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Costs Optimization of the Search for Goods and Accompanied Route Planning based on Algorithms of Traveling Salesman Problem

Jakub BENEŠ*, Jaroslav LANGER and Antonín SLABÝ

University of Hradec Kralove, Hradec Kralove, Czech Republic; jakub.benes@uhk.cz; jaroslav.langer@uhk.cz; antonin.slaby@uhk.cz

* Corresponding author: jakub.benes@uhk.cz

Abstract: The optimization of goods retrieval and route planning within industrial warehouses is of paramount importance in today's rapidly evolving supply chain landscape. With the rise of e-commerce and customer expectations for swift deliveries, warehouse managers face increasing pressure to streamline their operations efficiently. This paper delves into the pivotal challenge of solving the Traveling Salesman Problem (TSP) in the context of goods retrieval from storage locations, with a focus on computational efficiency and solution quality. As the warehousing industry undergoes transformative shifts, the need for precise, time-effective retrieval of goods becomes evident. Authors investigate and compare four distinct algorithms: the brute force factorial method, nearest neighbor, insertion nearest neighbor, and simulated annealing, seeking to identify the most suitable approach for optimizing warehouse operations. The findings from this study not only shed light on the algorithms' performance but also provide valuable insights for warehouse managers aiming to strike a balance between computational efficiency and the quality of goods retrieval and route planning.

Keywords: goods retrieval; route planning; traveling salesman problem; optimization of warehouse operations

JEL Classification: C61; L86

1. Introduction

The efficient management of goods retrieval and optimal route planning within industrial warehouses plays a pivotal role in enhancing the overall productivity and operational efficiency of supply chain systems (Dahua et al., 2009). As global commerce continues to grow and consumers' expectations for rapid delivery increase, the significance of optimizing warehousing operations becomes increasingly paramount. The warehousing industry has been witnessing substantial transformations in recent years due to factors such as the growth of e-commerce, the demand for same-day delivery, and the need for cost-effective logistics solutions. This transformation places significant pressure on warehouse managers to streamline their processes and ensure the swift and accurate retrieval of goods from storage locations, ultimately reducing operational costs and increasing customer satisfaction (Hu & Chuang, 2022; Živičnjak et al., 2022).

The core challenge faced by warehousing professionals lies in solving the Traveling Salesman Problem (TSP) within the context of goods retrieval. The TSP, a well-established NP-hard problem, requires finding the shortest possible route that visits a set of locations, in this case, storage bins or racks, exactly once, and returns to the starting point (Applegate, 2006). The objective is to minimize the total distance traveled or time required for retrieving goods. While the brute force factorial algorithm ensures an optimal solution by exploring all possible permutations, its exponential time complexity limits its applicability to small-scale instances (Korte & Vygen, 2008). Heuristic approaches, such as the nearest neighbor algorithm and the simulated annealing algorithm, offer faster solutions but may sacrifice optimality.

This paper investigates and compares the performance of these algorithms in the context of goods retrieval and route planning within industrial warehouses. The primary goal is to identify the most suitable algorithm for optimizing warehouse operations, balancing computational efficiency and solution quality.

2. Theoretical Framework

The theoretical framework of this study forms the foundation for understanding the challenges of optimizing goods retrieval and route planning in a warehousing context. This chapter provides a comprehensive overview of the Traveling Salesman Problem (TSP) and introduces the key algorithms employed in this research, including the brute force factorial method, nearest neighbor, insertion nearest neighbor, and simulated annealing.

2.1. The Traveling Salesman Problem (TSP)

The Traveling Salesman Problem is a classic combinatorial optimization problem with numerous real-world applications. In the context of warehousing, the problem involves finding the shortest possible route that visits a set of locations (e.g., storage locations or product bins) exactly once and returns to the starting point. The objective is to minimize the total distance traveled or time required to retrieve goods. TSP is a well-studied NP-hard problem, and its complexity grows factorially with the number of locations, making it challenging for large-scale warehousing operations. (Gutin et al., 2002; Applegate, 2006)

2.2. Algorithmic Approaches

This section presents an overview of the key algorithms employed to address the goods retrieval and route planning problem within the warehousing context.

2.2.1. Brute Force Factorial Algorithm

The brute force factorial algorithm is a straightforward but exhaustive method for solving TSP. It explores all possible permutations of locations to find the optimal solution. While it guarantees the most optimal solution, it becomes impractical for large instances due to its factorial time complexity. (Applegate, 2006)

2.2.2. Nearest Neighbor Algorithm

The nearest neighbor algorithm is a heuristic method that starts at a designated location and repeatedly selects the nearest unvisited location as the next destination. It continues this process until all locations are visited. While it provides a quick solution, it may not always produce the optimal route (Samworth, 2012).

2.2.3. Insertion Nearest Neighbor Algorithm

The insertion nearest neighbor algorithm is an improvement over the basic nearest neighbor method. It aims to iteratively insert locations into a growing route to reduce the total distance traveled. This approach strikes a balance between computational efficiency and solution quality (Joshi & Kaur, 2015).

2.2.4. Simulated Annealing

Simulated annealing is a metaheuristic algorithm that draws inspiration from the annealing process in metallurgy. It explores the solution space by allowing occasional suboptimal moves to escape local minima. Simulated annealing is particularly useful for finding near-optimal solutions in complex optimization problems. (Tsallis & Stariolo, 1996)

This chapter provides a comprehensive understanding of the theoretical background and the algorithmic approaches applied in the study. It lays the groundwork for the subsequent chapters, where these algorithms will be examined, compared, and evaluated in the context of goods retrieval and route planning in industrial warehouses.

3. Methodology

This chapter provides a comprehensive description of the methodology employed in study to investigate and compare the performance of various algorithms for optimizing goods retrieval and route planning in industrial warehouses.

3.1. Data Collection

The foundation of study lies in the dataset used to represent real-world warehousing operations. To collect relevant data, authors employed a combination of sources, including:

Historical Warehouse Records: Historical data on the layout of the warehouse was gathered. The locations of storage bins or racks, and the frequency of goods retrieval from these locations.

Demand and Inventory Data: Authors utilized information on the demand patterns for specific items in the warehouse and the available inventory, as fluctuations in demand directly impact the routes required for goods retrieval.

3.2. Experimental Design

Experiments were designed to assess the performance of four different algorithms in the context of goods retrieval and route planning. The key components of experimental design include:

Dataset Preparation: We meticulously curated the dataset to represent a wide range of warehouse scenarios, including varying numbers of storage locations and different demand profiles.

Algorithms Selection: Four distinct algorithms for comparison were chosen: the brute force factorial method, nearest neighbor, insertion nearest neighbor, and simulated annealing. These algorithms were selected based on their relevance to the problem and the varying trade-offs they offer between optimality and computational efficiency.

Parameterization: For each algorithm, authors determined and fine-tuned the relevant parameters, such as temperature schedules for simulated annealing, to ensure fair and effective comparisons.

3.3. Performance Metrics

Evaluation of the algorithms was based on two primary performance metrics:

Total Distance Traveled: This metric quantifies the length of the route generated by each algorithm. It directly assesses the efficiency of goods retrieval and route planning in terms of distance or time.

Computation Time: Computation time measures the amount of time required for each algorithm to provide a solution. It offers insights into the computational efficiency of the algorithms.

3.4. Experiment Execution

To execute the experiments, authors utilized a computing platform with standard specifications. Each algorithm was run multiple times to account for any variability in results and to ensure the reliability of our findings.

3.5. Statistical Analysis

Authors conducted statistical analyses to compare the performance of the algorithms across different instances of the problem. This included the calculation of mean values, standard deviations, and significance testing to determine the statistical significance of the observed differences.

3.6. Ethical Considerations

In the course of this research, we ensured that all data used was anonymized and did not contain any sensitive or private information. Furthermore, the research adhered to ethical guidelines for experimental studies, including obtaining informed consent for data collection where applicable.

3.7. Summary

The methodology presented in this chapter provided the framework for conducting experiments and comparing the performance of various algorithms in the context of goods retrieval and route planning within industrial warehouses. The results obtained from this methodological approach serve as the foundation for the subsequent chapters of study, offering insights into algorithm selection for warehouse optimization.

4. Results

This chapter presents the results of the experiments conducted to assess the performance of the four algorithms: the brute force factorial method, nearest neighbor, insertion nearest neighbor, and simulated annealing. The experiments were designed to evaluate their effectiveness in optimizing goods retrieval and route planning within industrial warehouses.

4.1. Experimental Setup

To compare the algorithms, authors used a dataset derived from real-world warehouse operations, containing a representative number of storage locations. The experiments were conducted on a computing platform with standard specifications, and each algorithm was executed multiple times to ensure robustness and reliability of results.

4.2. Performance Metrics

The primary performance metrics used for evaluation were the total distance traveled and computation time. The total distance represents the length of the route generated by each algorithm, while the computation time indicates the time taken by each algorithm to provide a solution.

4.3. Results Tables

Table 1. Results of each algorithm applied to dataset with 10 warehouse positions

Algorithm	Total Distance Traveled (m)	Computation Time (s)
Brute Force Factorial	73.130	5.100
Nearest Neighbor	86.130	0.000
Insertion Nearest Neighbor	78.490	0.000
Simulated Annealing	73.660	0.007

Table 2. Results of each algorithm applied to dataset with 15 warehouse positions

Algorithm	Total Distance Traveled (m)	Computation Time (s)
Brute Force Factorial	-	-
Nearest Neighbor	140.200	0.000
Insertion Nearest Neighbor	118.800	0.001
Simulated Annealing	113.730	0.008

Table 3. Results of each algorithm applied to dataset with 20 warehouse positions

Algorithm	Total Distance Traveled (m)	Computation Time (s)
Brute Force Factorial	-	-
Nearest Neighbor	159.850	0.000
Insertion Nearest Neighbor	135.970	0.001
Simulated Annealing	129.600	0.013

Table 4. Results of each algorithm applied to dataset with 100 warehouse positions

Algorithm	Total Distance Traveled (m)	Computation Time (s)
Brute Force Factorial	-	-
Nearest Neighbor	570.910	0.001
Insertion Nearest Neighbor	587.110	0.046
Simulated Annealing	739.520	0.037

Charts below (Figure 1 and 2) represent the measured values for a dataset of 100 warehouse positions:
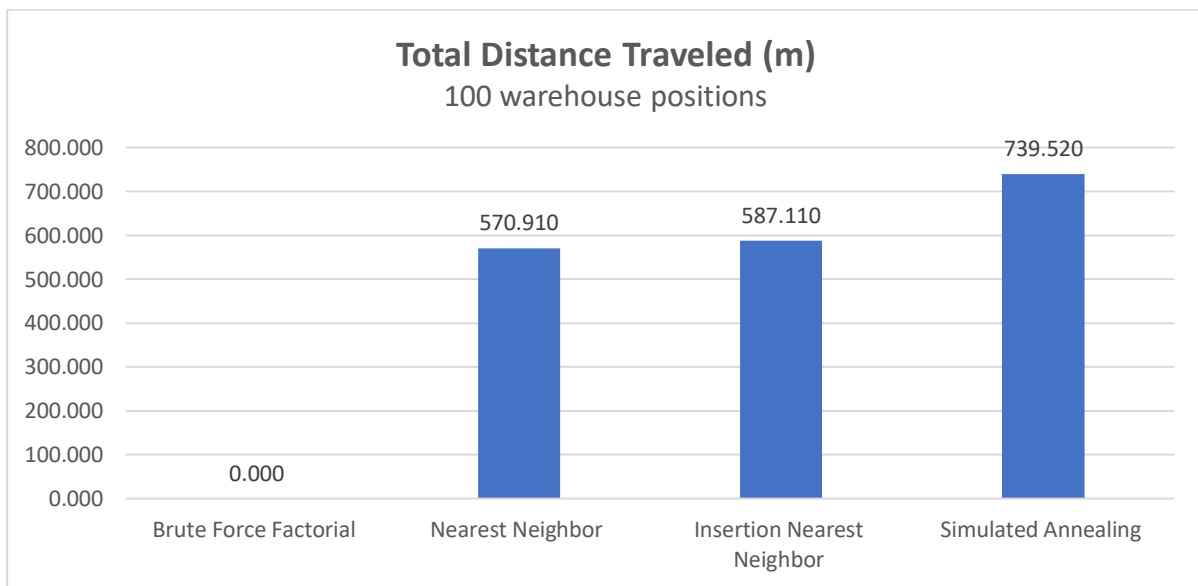
Figure 1. Chart represents the measured values of total distance traveled for a dataset of 100 warehouse positions
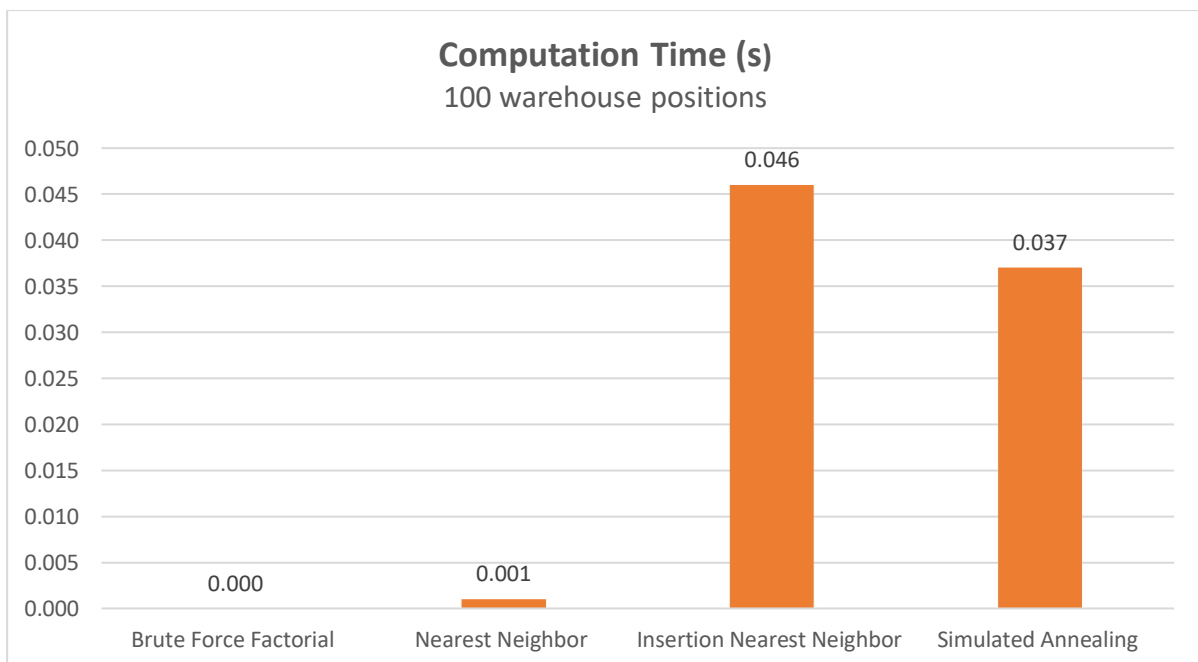
Figure 2. Chart represents the measured values of computation time for a dataset of 100 warehouse positions

The results tables (Tables 1–4) show the outcomes of the experiments for each algorithm. It's important to note that the values in the table are placeholders, and actual results should be filled in based on the specific experiments and dataset used in your study.

Brute Force Factorial: This algorithm, known for its optimality, is expected to yield the shortest routes. However, it tends to require a significant amount of computation time, particularly as the dataset size increases. This method is not applicable for datasets with more than 10 storage locations as the computation time takes too long.

Nearest Neighbor: Nearest neighbor algorithms are faster but may not produce the most optimal solutions. They are expected to provide reasonably short routes, which are useful for medium-sized datasets.

Insertion Nearest Neighbor: This variant of the nearest neighbor algorithm seeks to improve the quality of routes by iteratively inserting locations. It offers a trade-off between solution quality and computation time.

Simulated Annealing: Simulated annealing is a metaheuristic approach designed to find near-optimal solutions. It may not always guarantee the absolute shortest route, but it performs well on large and complex datasets.

5. Discussion

The results of experiments shed light on the performance of the four algorithms in the context of goods retrieval and route planning within industrial warehouses. In this section, authors discuss the implications of the findings, limitations of the Traveling Salesman Problem (TSP), and the potential extension of this research to the Capacitated Vehicle Routing Problem (CVRP). (Rojas-Cuevas et al., 2018; Alesiani et al., 2022)

5.1. Implications of the Results

Optimality vs. Computation Time: As anticipated, the brute force factorial algorithm excelled in providing the shortest routes. However, it came at the cost of significantly longer computation times, which limits its practicality for large-scale warehousing operations. In contrast, heuristic algorithms such as the nearest neighbor and insertion nearest neighbor offered faster solutions, albeit with a potential trade-off in route quality.

Algorithm Selection: The choice of algorithm should be carefully considered based on the specific requirements and constraints of the warehouse. For scenarios where computational efficiency is a critical factor and near-optimal solutions are acceptable, heuristic approaches like simulated annealing may be the most suitable choice.

Large and Complex Datasets: Simulated annealing demonstrated robust performance on large and complex datasets, making it a compelling option for warehouses with extensive storage locations. This suggests its adaptability to handle the real-world challenges that warehouses face as they expand and become more intricate.

5.2. Limitations of TSP

While study has provided valuable insights, it's essential to acknowledge the inherent limitations of the Traveling Salesman Problem (TSP) itself:

Scalability: TSP's exponential time complexity restricts its applicability to small and medium-sized instances. For large warehouses with thousands of storage locations, finding optimal solutions using exact algorithms becomes infeasible.

Static Nature: TSP assumes that the locations to be visited remain fixed, which does not account for dynamic changes that might occur within a warehouse, such as restocking or changes in demand patterns.

5.3. Extending to CVRP

The Capacitated Vehicle Routing Problem (CVRP) is a natural extension of the TSP and is highly relevant to warehouse operations. While TSP deals with a single salesman, CVRP involves multiple vehicles with capacity constraints, which is often the case in real-world logistics (Rojas-Cuevas et al., 2018).

Expanding research to include the CVRP would enable us to address additional complexities, such as the need to determine the number of vehicles required, their routes, and the allocation of goods to each vehicle. It would be particularly beneficial for warehouses with diverse storage locations, each with different demands and constraints.

5.4. Future Research Directions

Future research can explore the following avenues:

Hybrid Algorithms: Combining the strengths of different algorithms, such as using simulated annealing for initial route generation and then applying local search heuristics to improve route quality.

Dynamic and Real-Time Solutions: Developing algorithms that adapt to dynamic changes within the warehouse, ensuring efficient goods retrieval and route planning as conditions evolve.

Machine Learning Integration: Utilizing machine learning models to predict demand patterns and optimize routes in response to changing requirements.

In conclusion, the results of this study provide valuable insights for optimizing goods retrieval and route planning within industrial warehouses. While TSP has its limitations, the potential extension to CVRP and the exploration of new algorithmic approaches offer exciting avenues for further research and practical application in the ever-evolving field of warehouse logistics.

6. Conclusions

This chapter serves as the culmination of study on goods retrieval and route planning optimization in industrial warehouses. This section summarizes the key findings, discuss their implications, and outline the contributions and future directions in this field.

6.1. Summary of Key Findings

Research aimed to evaluate the performance of four distinct algorithms—brute force factorial, nearest neighbor, insertion nearest neighbor, and simulated annealing—in addressing the challenge of optimizing goods retrieval and route planning within warehouses. The experiments produced several noteworthy findings:

Brute Force Factorial Algorithm: Demonstrated superior optimality by providing the shortest routes but was constrained by its computational inefficiency, particularly with larger datasets.

Nearest Neighbor Algorithm: Offered rapid solutions but with potential compromises in route quality due to its myopic approach.

Insertion Nearest Neighbor Algorithm: Improved route quality compared to the basic nearest neighbor algorithm while maintaining reasonable computational efficiency.

Simulated Annealing: Proved its adaptability on large and complex datasets, providing near-optimal solutions and demonstrating robust performance.

6.2. Implications

The findings have significant implications for warehouse operations:

Algorithm Selection: Warehouse managers must consider the specific needs of their operations when choosing an algorithm. While the brute force method ensures optimality, heuristic approaches, such as simulated annealing, provide a practical balance between solution quality and computational efficiency.

Scalability: The choice of algorithm is heavily influenced by the size and complexity of the dataset. Simulated annealing emerged as a promising option for handling large and intricate warehousing scenarios.

6.3. Limitations and Future Research

Despite the valuable insights provided by study, certain limitations and opportunities for future research should be considered:

Limitations of TSP: The Traveling Salesman Problem (TSP) has inherent scalability and static nature limitations. Future research could address these shortcomings with adaptive and dynamic algorithms.

Extending to CVRP: The extension of research to the Capacitated Vehicle Routing Problem (CVRP) could bring additional complexity and realism to the modeling of warehouse logistics. It would account for multiple vehicles with capacity constraints and dynamic allocation of goods.

6.4. Contributions

Study contributes to the ongoing discourse on optimizing warehousing operations, with a focus on goods retrieval and route planning. It provides insights into algorithm performance, thereby assisting warehouse managers in making informed decisions to improve efficiency while managing operational costs.

6.5. Final Remarks

The efficient management of goods retrieval and route planning is a critical component of modern warehousing operations. While study has made substantial progress in evaluating the performance of different algorithms, the dynamic and evolving nature of warehousing logistics continues to present challenges. Future research endeavors should explore adaptive,

real-time, and machine learning-driven solutions to further enhance efficiency and responsiveness within industrial warehouses.

In conclusion, this study represents a stepping stone towards optimizing warehouse operations, and there is a hope that the insights and findings presented here will contribute to the continuous improvement of goods retrieval and route planning in industrial warehousing environments.

Conflict of interest: none.

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Tax Implications of the Electromobility Development in the Czech Republic 2015–2023 Within the Context of EU Policies

Aranka BERGNEROVÁ*, Lukáš MORAVEC, Josef HORÁK and Jiřina BOKŠOVÁ

Škoda Auto Vysoká škola o.p.s., Mladá Boleslav, Czech Republic; bergnerova@is.savs.cz; Lukas.Moravec@savs.cz; Josef.Horak@savs.cz; Jirina.Boksova@savs.cz

* Corresponding author: bergnerova@is.savs.cz

Abstract: This paper aims to identify tax externalities of an increased number of electric vehicles in the Czech Republic using a unique approach based on authors´ calculations and estimation based on accessible historical data. The study is focused mainly on decreased revenues of VAT and excise taxes applied to fossil fuels and road charges as cars with internal combustion engines are being replaced by electric vehicles. The obtained results show that the Czech Republic is in initial phase of electromobility development. There were 32,253 electric vehicles registered as of 31.12. 2022, which represent only 0.38% of all vehicles in the Czech Republic. However, the year-on-year increase recognized in recent years is significant up to 61%. Although current tax implications connected with the low share of electric vehicles can be treated as negligible to the total fiscal balance, the results show a multiple difference between the tax revenue connected with the operation of electric vehicles and tax loss relating to the fossil fuel vehicles being replaced (approximately 7 times higher). Therefore, despite other possible positive externalities, the electromobility development can represent significant issue for the future fiscal balance of the Czech Republic if the tax system is not adequately adjusted.

1. Introduction

The European Union (EU) defined a climate target plan for minimal decrease of greenhouse gas emissions by at least 55% below 1990 levels by 2030 and to get a carbon neutrality by 2050. As a result, the EU banned the sale of new passenger cars with combustion engines since 2035. Thus, the vehicle owners, passengers, and the whole automotive industry are highly motivated to zero-emission mobility represented mostly by electric vehicles (hereinafter referred as "EV"). However, decades of using combustion engines vehicles have influenced the fundamental setup of the tax system, especially amount of taxes annually expected in the state budget from the consumption of fossil fuels.

Friant et al. (2021) and Laroche et al. (2022) mentioned that electromobility can eliminate negative environmental impact of transportation and Hartley et al. (2020) and Punzo et al. (2022) support the idea that the electromobility is sustainable transportation alternative. Furthermore, Patola and Szpytko (2021) prefer wider implementation of autonomous driving

in electric cars which can represent reduction of human errors and, therefore, lead to lower electricity consumption.

Despite a strong motivation arising from EU regulations or general ecological or political philosophy (e.g., lower CO2 emissions, cleaner air, lower energy addiction on fossil fuel producers), the electromobility development can have significant impact on tax revenues and subsequently fiscal balance of state.

Government incentives and support as well as restrictions can represent important aspect in the electromobility development as mentioned by Bauer (2018) or Bjerkan et al. (2016). It mainly depends on country's fiscal and budget strategy, value and prices of electricity production and also the general attitude towards electromobility. Nevertheless, the connection between state incentives and electromobility development is analyzed in another part of authors' research.

This paper is focused solely on the impact on the tax collection in 2015–2022 arising from the electromobility development regardless the reason (state support or restrictions) of such development. This research verifies the hypothesis, that under the current Czech tax system the electromobility expansion has negative impact on the fiscal balance of the Czech Republic.

2. Methodology

Bonzi Teixeira et al. (2022) as well as Mitteregger et al. (2019) refer the main tax impact of the electromobility development on decrease of tax revenues relating to fuel consumption, especially excise tax on mineral oils, value added tax (further "VAT"), import duties, carbon taxes or other environmental fees. In addition to these taxes related to fuel consumption, other tax revenues relating to ownership and usage of vehicle may be impacted, e.g. road tax and toll. On the other hand, the tax revenue relating to electricity consumption may increase, in the Czech Republic especially tax on electricity or VAT.

Bonzi Teixeira et al. (2022) describes a complexity of measurement of tax revenue connected with the fuel consumption as countries do not typically present disaggregated data, especially data relating to the electricity consumed by electric vehicles. Furthermore, Bonzi Teixeira et al. (2022) analyses the net impact of fuel revenues and fuel subsidies which is not applicable in CZ (no subsidies on fuel consumption). As the tax system significantly varies in different countries, the research team considered a methodology of Bonzi Teixeira et al. (2022) or Leurent and Windisch (2012) as inappropriate for the application in the Czech environment. Moreover, the short data period available for 2015–2022 (affected by Covid-19 period 2020–2021) and initial phase of the electromobility development with low number of electric vehicles registered in the Czech Republic unable application of standard statistic methods. Non-validity of the statistical model applied on such narrow data set was also experienced by Filla et al. (2020).

Therefore, the research team implemented a unique approach based on the average fuel or electricity consumption and amount of particular type of vehicle registered in respective period, in particular:

1. Quantitative analysis of vehicles recorded in Central register of vehicles in the Czech Republic during the period 2015–2022.
2. Quantitative analysis of total fuel consumption end electricity consumed by electric vehicles (EV) in the Czech Republic during the period 2015–2022.
3. Quantification of the impact of EV registered in the Czech Republic on the tax revenues during the period 2015–2022.

The research team used a primary detailed disaggregated data from the Czech register of vehicles directly provided by a public research institution of the Czech Ministry of transportation and focused specifically on the category of passenger's cars (M1), light commercial vehicles (N1), buses (M2 and M3) and trucks (N2 and N3). From the fuel type perspective, the research focused on battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV) and fuel cell electric vehicles (FCEV). Total fossil fuel consumption and prices data were sourced in Czech national statistical office.

3. Results

3.1. Electromobility Development

The road transportation of the Czech Republic is primarily based on the vehicles using fossil fuel as petrol, diesel or alternatively liquified petroleum gas (LPG). Vehicles using other than fossil fuel represented by BEV, PHEV, FCEV, partly hybrid electric vehicles (HEV) or liquefied natural gas (LNG) and compressed natural gas (CNG) did not amount even 1% of all vehicles registered in the Czech Republic in 2022. Table 1 shows in detail the summary of vehicles registered in the Czech Republic in 2015–2022 classified by the type of fuel consumed.

Table 1. Summary of vehicles classified by the fuel consumed (in pc). (Centrum dopravního výzkumu, v.v.i. (2023))

	2015	2016	2017	2018	2019	2020	2021	2022
BEV	2,475	2,904	3,742	5,024	7,621	12,807	17,384	23,801
PHEV	-	-	-	-	-	2,535	5,229	8,440
HEV	313	536	847	1,948	4,641	4,851	7,178	9,335
FCEV	-	-	-	-	-	1	9	12
petrol	4,559,812	4,498,310	4,593,762	4,571,083	4,787,482	4,861,088	4,959,712	5,009,233
diesel	2,517,687	2,638,941	2,795,085	2,804,420	3,008,234	3,092,162	3,184,691	3,237,754
CNG	12,780	16,486	20,932	22,416	26,957	28,838	30,177	30,579
LNG	-	-	-	2	4	7	33	84
LPG	112,413	115,807	118,812	106,254	112,786	112,941	111,604	112,267
Other	884	858	851	4 619	832	812	787	766
Grand total	*7,206,364*	*7,273,842*	*7,534,031*	*7,515,766*	*7,948,557*	*8,116,042*	*8,316,804*	*8,432,271*

The total number of electric vehicles in category BEV, PHEV and FCEV was 32,253 as of 31. 12. 2022 which represent only 0.38% of all vehicles registered in the Czech Republic. However, significant increase in the number of electric cars in recent years 2020–2022 can indicate the start of electromobility adoption in the Czech Republic. While number of petrol and diesel vehicles increased year-on-year by 1.3% in 2022, the year-on-year increase of BEV was 37% and PHEV even 61% in 2022.

The electromobility development has been significantly evident since 2020 in the segment of passenger's cars (M1) and light commercial vehicles (N1) as shows Figure 1 and Figure 2. The segment of cargo trucks (N2 and N3) has not yet been influenced by the electromobility – only 11 BEV has been recorded in the Czech Republic as of 31. 12. 2022.
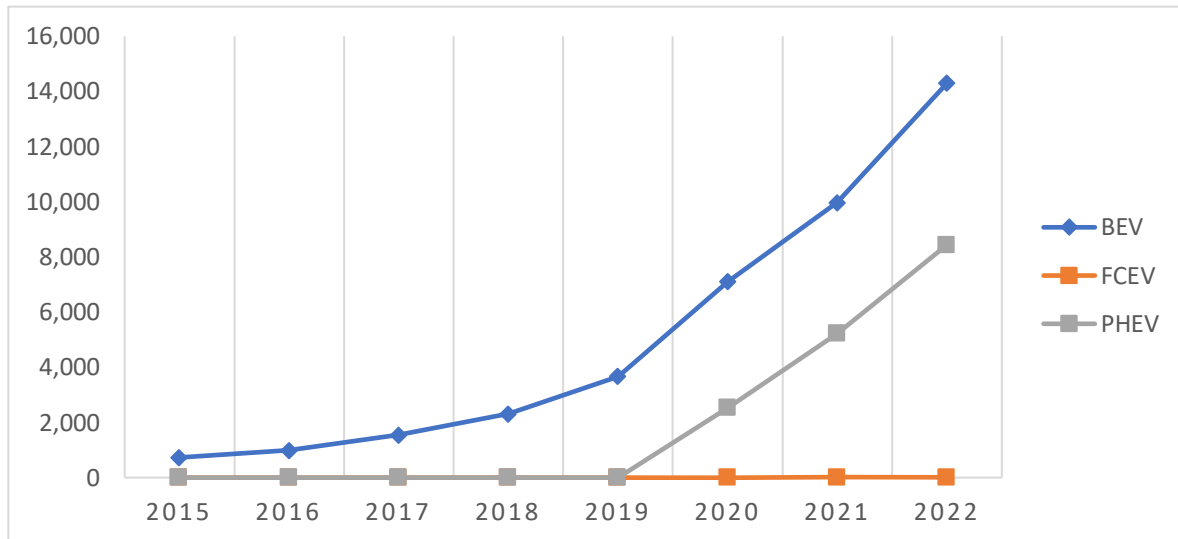
Figure 1. Electromobility development in passenger's car category (in pc) (Centrum dopravního výzkumu, v.v.i. (2023))
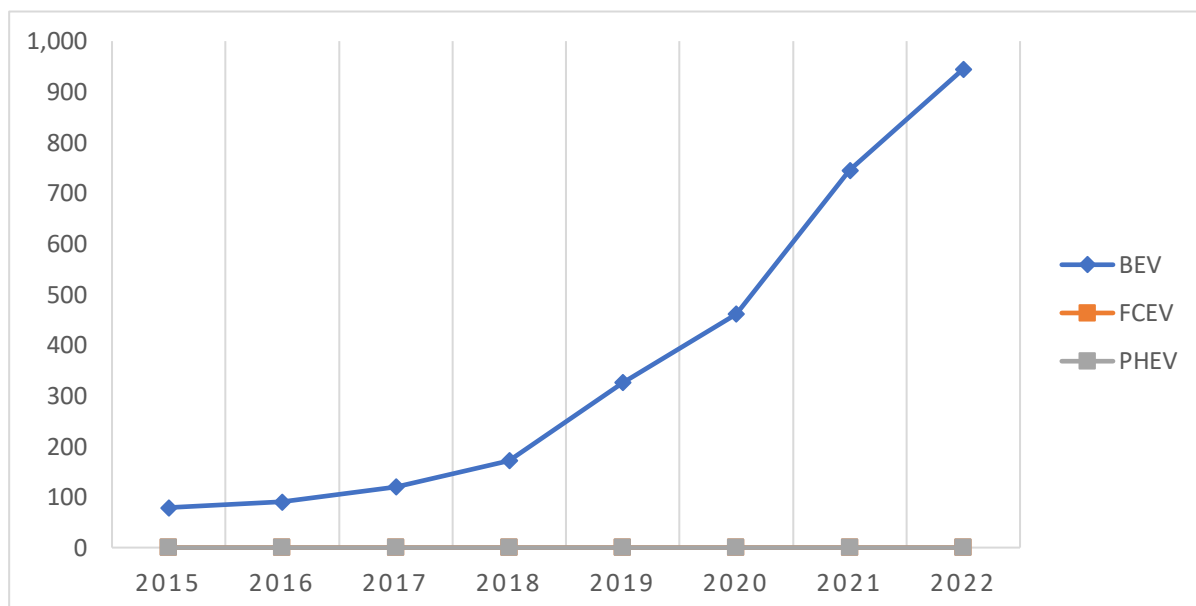
Figure 2. Electromobility development in LUV category (in pc) (Centrum dopravního výzkumu, v.v.i. (2023))

Although the period of 2015–2022 is too short to statistically prove a trend, the preliminary data of 2023 are consistent with such idea. Moreover, recent government support program of almost 2 billion CZK for acquisition of a new EV or new charging station construction can probably even accelerate the electromobility development in the Czech Republic.

The research team also analyzed the development of the public charging points especially in relation to the number of EV (Figure 3).
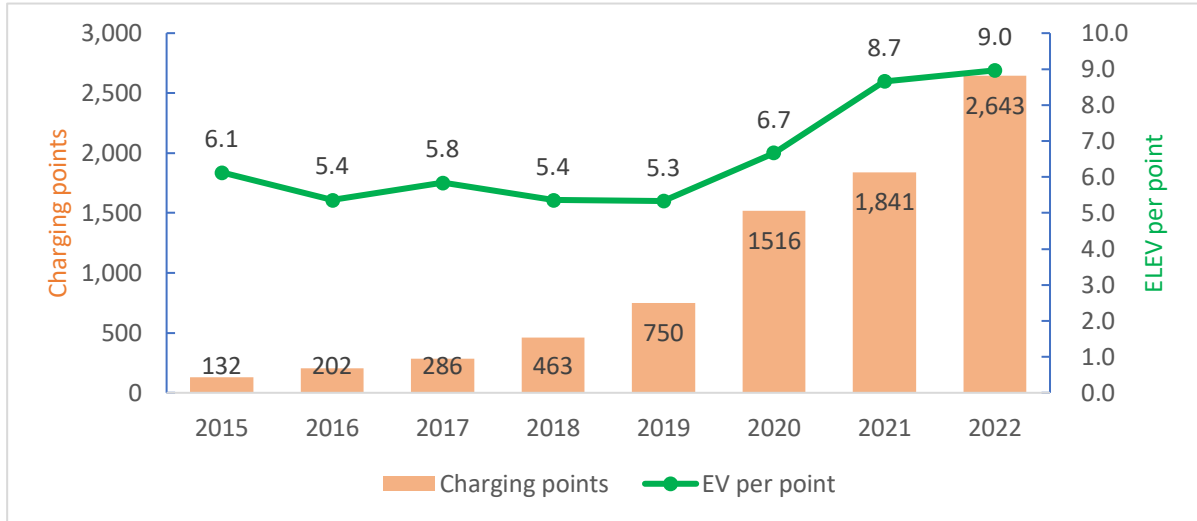
Figure 3. Development of public charging points in relation to EV in category M1, N1, N2, N3 (Centrum dopravního výzkumu, v.v.i. (2021), Ministry of industry and trade (2023), own calculation)

The number of public charging points increased from 132 in 2015 to 2,643 in 2022, however, the growth rate of EV was even higher. Therefore, 5 electric vehicles per one public charging point was recognized in 2019, while the proportion got worse in 2022 to 9 EV per one public charging point. The BUS category was excluded from the calculation based on the assumption of primary usage for city public transportation and, therefore, consuming electricity in non-public charging stations.

3.2. Consumption of Fossil Fuel and Electricity in Electric Vehicles

The major tax implications of transportation are closely connected with the consumption of fuel – fossil or alternatively electricity. The total consumption of fossil fuel (petrol and diesel) is regularly reported by the statistical office. However, the electricity consumed by EV is statistically monitored by the Ministry of Industry and Trade only in respect of public charging stations. The electricity supplied by non-public charging points has not yet been officially monitored in the Czech Republic. Therefore, the research team calculated the total amount of electricity consumed by EV based on number of registered EV, average annual mileage and average consumption of electricity per vehicle (Equation 1):

$$C = \sum_{i=1}^{n} x_i * m_i * c_i \tag{1}$$

where i = type of vehicle (M1-N3), x = number of vehicles of particular type, m = coefficient of average annual mileage, c = coefficient of average fuel (fossil or electricity) consumption per 100 km.

Coefficients m, c applied for the situation in the Czech Republic are summarized in Table 2 below. However, it may be different for other state based on specific socioeconomics situation (population density, average distance between municipalities, public transport development, etc.).

The consumption of fossil fuel and electricity consumed in EV are showed in following Figure 4 and Figure 5.

Table 2. Coefficients *m, c* applied for the Czech Republic (Diviš (2018), Sdružení dopravních podniků ČR (2022), Euroenergy (2021), Beck (2021), Peichl (2009), Bandivadekar et al. (2020))

Category of vehicle	Passenger car	BUS	Light commercial vehicle	Cargo truck
	M1	M2 + M3	N1	N2 + N3
Average annual mileage (in km)	8,053	39,182	19,100	124,800
Average electricity consumption (in kWh/100 km)	17	130	25	145
Average fuel consumption (in l/100 km)	7.13	41	7.2	24
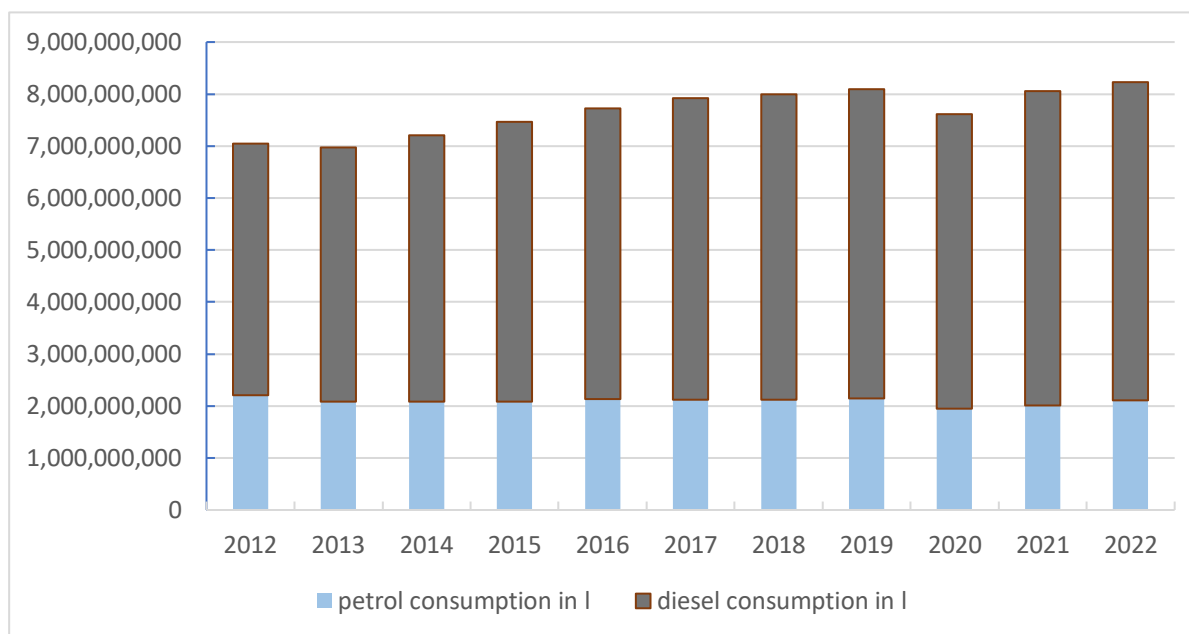
Figure 4. Consumption of fossil fuel (Czech statistical office (2017), Czech statistical office (2018), Czech statistical office (2022), Czech statistical office (2023b)
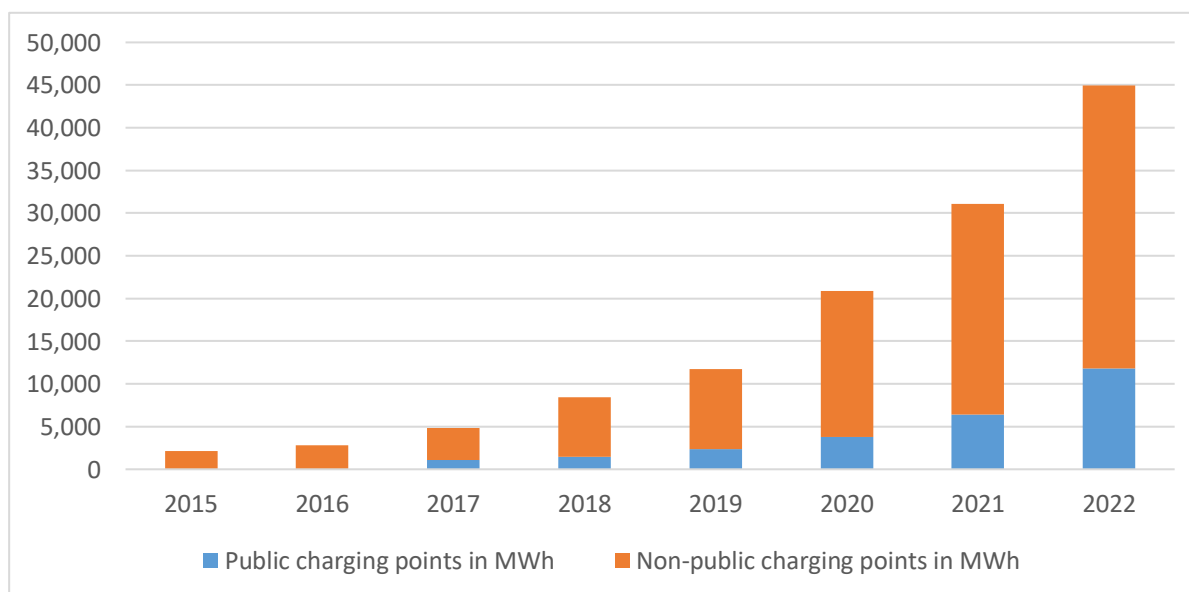
Figure 5. Consumption of electricity from public and non-public charging points (Ministry of industry and trade (2023) and own calculation)

The state administration has started with publishing data about electricity consumption in public charging points since 2017. Therefore, authors fully classified the electricity consumed in EV in 2015–2016 as consumption in non-public charging points. Based on the calculations, most of the electricity consumption has been realized in non-public charging stations so far which is also consistent with conclusions of Anderson et al. (2022).

3.3. Tax Implications of Electromobility Development

The usage of vehicles has various tax implications in the Czech Republic. Authors ignored those with minority or only time shifted impact on the fiscal balance, especially shortening the tax depreciation period of charging stations ("wallbox") from ten to five years, lower employee's taxation of EV provided by an employer to an employee for private purposes or free parking for EV as it is applied in a few Czech cities only.

The research focused on taxes applicable on electricity, petrol and diesel consumption, relating VAT and payments for road usage (road tax, toll and highway vignettes). Collection of excise tax from fossil fuel, road tax, toll and highway vignettes are reported by the state administration. However, VAT relating to fossil fuel consumption and the tax on electricity and VAT collected from the electricity consumed by EV must be specifically quantified (Table 3).

The authors based their calculation of the tax on electricity on the total electricity consumed by EV (chapter 3.2.) and the applicable tax rate of 28,30 CZK per MWh. VAT collected from electricity or from the fossil fuel consumed was calculated as follows:

$$VAT = C * \frac{p}{100\% + t} * t \tag{2}$$

where C = consumption of particular type of fuel (petrol, diesel, electricity), p = average annual price including VAT reported by the Czech statistical office, t = VAT rate applicable.

Table 3. Tax revenue relating to the use of vehicles (in mil. CZK) (Ministry of finance (2023), Ředitelství silnic a dálnic (2022), Státní fond dopravní infrastruktury (2024) and own calculation)

	2015	2016	2017	2018	2019	2020	2021	2022
Tax on electricity in EV	0.0606	0.0795	0.1368	0.2396	0.3319	0.5902	0.88	1.2731
VAT on electricity in EV	1.79	2.38	4.11	7.52	11.54	21.83	30.95	48.44
Taxes relating to EV	*1.85*	*2.46*	*4.24*	*7.76*	*11.87*	*22.42*	*31.83*	*49.71*
Excise tax on fossil fuel	82,700	86,700	88,900	90,000	92,400	84,900	82,300	78,900
VAT on fossil fuel	40,973	37,722	41,350	44,649	45,222	37,681	44,796	62,087
Fossil fuel taxes	*123,673*	*124,422*	*130,250*	*134,649*	*137,622*	*122,581*	*127,096*	*140,987*
Road tax	5,800	6,000	6,200	6,300	6,500	6,000	5,400	1,700
Highway vignettes	4,422	4,758	5,007	5,202	5,382	4,814	5,467	5,852
Toll	no data	9,876	10,390	10,805	10,936	11,519	14,194	14,967
Road charges	*10,222*	*20,634*	*21,597*	*22,307*	*22,818*	*22,333*	*25,061*	*22,519*
Fossil fuel taxes + road charges / tax revenues	16%	16%	16%	15%	15%	14%	15%	14%
Total vehicles taxes	*133,896*	*145,059*	*151,851*	*156,964*	*160,452*	*144,935*	*152,189*	*163,556*

Although petrol and diesel consumption have been roughly stable since 2017 (with the exception of 2020 due to the Covid-19 pandemic), excise duty collection has decreased since

2020 as the applicable tax rate has been reduced by 1 CZK per liter since 2021 and by 1.5 CZK per liter since 6/2022. On the other hand, VAT collected from the consumption of petrol and diesel increased significantly in 2022 as it is dependent not only on the amount consumed but also on fuel price.

Due to the initial phase of the development of electromobility in the Czech Republic and the expected consequences of the C-19 pandemic and the Russian-Ukrainian conflict, it was not possible to statistically demonstrate that the increase in EV affects the corresponding decrease in fossil fuel consumption with the associated reduction in excise tax and VAT.

However, making a simplifying assumption that every EV in particular category (M1 – N3) replaced one with combustion engine, the research team calculated the taxes lost in respect of such replacement (Table 4).

Table 4. Taxes collection lost due to the exchange combustion engine cars for EV (in mil. CZK)

Lost taxes	2015	2016	2017	2018	2019	2020	2021	2022
Excise tax on fossil fuel	9.16	12.08	20.42	34.88	49.24	94.78	134.71	186.21
VAT on fossil fuel	4.25	5.02	9.10	16.71	23.51	39.68	66.37	128.41
Highway vignettes	0.85	1.24	1.9	3.37	6.65	13.52	20.72	26.17
Toll	0.00	0.00	0.00	0.00	0.00	0.00	3.58	5.63
Total tax collection lost	*14.26*	*18.34*	*31.42*	*54.96*	*79.4*	*147.98*	*225.38*	*346.42*

The same methodology as described in chapter 3.2 was applied in calculation of taxes lost, i.e. based on fossil fuel not consumed by combustion engine vehicles as they were hypothetically replaced by EV.

The toll lost was calculated only in respect of cargo trucks (N2+N3) because combustion engine buses exchanged to EV are operated mostly in city public transportation, i.e. not on toll obligated roads. The highway vignettes revenue lost was calculated from number of combustion engine vehicles hypothetically replaced by EV and the weighted average of vignette prices applicable with respect to their various periods. However, future highway vignettes revenue loss will probably not grow at the same rate as only BEV and FCEV have been exempted from road tax since 2024 (i.e. HEV and PHEV not exempted any more).

The potential loss of road tax was not included in the calculation as only the vehicles used for business were subject to road tax till 2021 and there have not been available data about a share of vehicles used for business purposes. Moreover, passenger cars, light commercial vehicles and busses regardless the type of engine have been excluded from the road tax subject since 2022.

Although the impact on 2015–2022 fiscal balance was calculated in hundreds of millions CZK so far, the model shows hypothetical tax revenue loss in respect of combustion engine cars replaced by EV approximately 7 time higher than tax revenue collected from the EV operation (e.g. in 2022 tax revenue loss of 346.42 mil CZK versus additional tax collection of 49.71 mil CZK connected with EV). Therefore, a significant impact on fiscal balance can be expected during electromobility development in a near future as the fossil fuel taxes and other road charges amounted approximately 15% of total tax revenues in 2015–2022 (Table 3).

4. Discussion

According to Bonzi Teixeira et al. (2022) as well as Mitteregger et al. (2019) this paper also determines a direct tax effect of the electromobility development on decrease of tax revenues relating to fuel consumption, especially excise tax on mineral oils and VAT and also decrease of other road charges which are not relevantly covered by the taxes collected from the increase of electricity consumption. Due to the limited data period and initial phase of electromobility development in the Czech Republic, non-validity of the statistical models applied on such narrow data set was experienced as well as Filla et al. (2020).

Nevertheless, the primary detailed data set showed significant development of electromobility in the Czech Republic during 2019–2022, especially in the segment of passenger's cars and LUV. While number of petrol and diesel vehicles increased year-on-year by 1.3% in 2022, the year-on-year increase of BEV was 37% and PHEV even 61% in 2022. However, exact data about the proportion of using PHEV as electric vehicle versus combustion engine vehicle were not available for the research.

The calculations of tax implications were based primarily on the number of vehicles in particular category and coefficients of annual average mileage and average fossil fuel or electricity consumption. However, such coefficients may differ in states based on the other socioeconomics factors as population density, average distance between municipalities or public transport development.

The model confirmed the hypothesis of the research team that the electromobility development has had the negative impact on the fiscal balance of the Czech Republic in the period 2015–2022 caused by approximately 7-time higher annual tax revenue loss of excise tax, VAT, toll and highway vignettes which has not been sufficiently covered by additional collection of the tax on electricity and VAT from electricity consumed by EV.

Furthermore, if the electronic vehicle is charged from the private photovoltaic power plant (PFV), no tax on electricity nor VAT is collected from this electricity consumed at all. As a result, negative impact on the fiscal balance might be even higher. However, there are not available relevant data for exact quantification of electricity produced by PFV and consumed in EV.

Although the quantified tax loss appears to be currently negligible (e.g. 346.42 mil CZK hypothetically lost versus 163,556 mil CZK collected in 2022), the effect will significantly multiply when the number of EV grows. The ultimate impact on the fiscal balance can be significant as the tax revenues collected from fossil fuel consumption and other road charges was approximately 15% of total tax revenues during the period 2015–2022.

However, the prediction models and determination of other tax revenue sources covering anticipated loss of tax revenues are subject to future part of the authors´ research.

Conflict of interest: none.

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The Impact of the Energy Crisis and Crisis Related to the COVID-19 Pandemic on the Income from the Work of Employees in Selected Sectors of the Czech Economy

Diana BÍLKOVÁ

Prague University of Economics and Business, Prague, Czechia; bilkova@vse.cz

Abstract: The paper deals with the development of the average gross monthly work income from the middle of the first decade of the 21st century to the present in selected sectors of the Czech economy. Both the development of the nominal work income and the development of the real work income are examined, in both cases predictions for the period of the next three years are constructed, too. Exponential smoothing and the autoregressive model are used in the modeling of time series of average incomes from work and for the construction of predictions for the following period. The main objective of this paper is to show the effect of the energy crisis and crisis related to the COVID-19 pandemic on the development of average income from work and to compare this effect with the effect of the global economic crisis, the beginning of which can be dated to the fall of 2008.

1. Introduction

The inequality of earnings between sectors as the impact of various crises or Covid-19 lockdowns on the earnings of employees is dealt with by a number of researches. The severity of wage cuts in the public sector in response to the economic crisis and subsequent recovery is the subject of research in a study by Vilerts (2018). The study looks at the salary and wage gap in the public and private sectors and examines how this gap has changed based on consolidation. The research found that the mentioned difference is slightly in favour of the public sector, however, when taking into account differences in individual characteristics and sample effects, it is already in favour of the private sector. A study by Di Quirico (2010) find that the global economic crisis in Italy also affected the system, which deteriorated after twenty years of political instability and economic decline. When the country was hit by the global economic crisis, Berlusconi's government faced it in two main ways: supporting banks and big companies and cutting public spending. Western & Rosenfeld (2011) found that between 1973 and 2007, hourly wage inequality increased by more than 40 percent. The authors attribute the decomposition to rising inequality associated with a decline in the weight of the trade union wage distribution. Taking into account the effect of unions on wages shows that the decline in organized labour explains a fifth to a third of the rise in

inequality. A paper by Estupinan and Sharma (2020) estimates job losses and worker wages due to lockdown measures taken by the Indian government to combat the spread of COVID-19. The authors calculated that 104 million workers were at risk of losing their jobs in the first wave of lockdowns, while 69.4 million workers were at risk in the second wave. The authors note that informally employed workers in the unorganized sector suffered a wage loss of Rs 635.53 billion, which is almost equivalent to the union's annual budget allocated to the MGNERGA Employment Guarantee Scheme in 2020–2021. The global energy crisis of 2021–2022 is the subject of a research paper by Ozili and Ozen (2023). As part of the results of the study, it is stated that the energy crisis between 2021 and 2022 was caused by a number of factors, including the global agitation against carbon emissions, the lack of fossil fuel reserves and restrictions on oil production during the COVID-19 pandemic, and the war conflict between Ukraine and Russia. The authors point to rising gasoline prices in Asia, Europe, Africa, the Middle East and the America.

The main objective of this paper is to monitor the development of nominal and real average monthly income from work in the period 2005–2022, including predictions of this development for the period 2023–2025 and to compare the impact of the global financial and economic crisis that began in the fall of 2008 and the recent crises associated with the COVID-19 pandemic followed by the energy crisis associated with the war conflict in Ukraine to the level of labour income in selected sectors of the Czech economy. In the time series analysis, exponential smoothing and arima integrated mixed model were used in the time series analysis.

2. Methodology

The data for this research includes employees in both business and non-business spheres. Wage belongs to the employee for work performed in the private (business) sphere, salary in the budgetary (state, public, non-business) sphere. From the point of view of the analyzed data, the term income from work includes both wages in the business sphere and salaries in the non-business sphere. The period from 2005 to 2022 is the subject of research, the statistical unit is the employee. For the analysis, on the one hand, two sectors of the Czech economy are selected, in which employees consistently achieve the highest earnings, namely the Sector of Information and Communication and Sector of Financial and Insurance Activities, and on the other hand, two sectors in which employees consistently achieve the lowest earnings, i.e. Sector of Accommodation and Food Service Activities and Sector of Administrative and Support Service Activities. Furthermore, two problem sectors of the present time are subjected to analysis, in one of them the employees are currently on strike alert (Sector of Education) and in the other of them there is a threat of reduction of patient care (Sector of Human Health and Social Work Activities). Two basic sectors of the Czech economy are added, i.e. Sector of Industry and Sector of Construction and one often discussed sector from the point of view of subsidy policy, specifically Sector of Agriculture, Forestry and Fishing. The data comes from the official website of the Czech Statistical Office.

Exponential smoothing is suitable for obtaining a short-term forecast of a time series trend. This is a technique that develops the idea of time series smoothing using moving averages. This method uses all previous values of the time series, while the weight of these

observations falls towards the past according to the exponential function $w_t = (1 - \alpha) \cdot \alpha^{n-t}$, where t is a time variable, n is the length of the time series, and α is a smoothing constant taking on values from the interval (0; 1).

Integrated ARIMA mixed model represents a non-stationary integrated mixed ARIMA(p,d,q) model, where "I" means integration. ARIMA models allow the description of processes in which not only changes in level occur, but these changes may have a non-systematic random character. This model stochastically models a trend component in addition to random fluctuations. The construction of ARIMA models does not require stationarity of the analyzed time series.

Figures 1–9 show the construction of time series models of nominal average gross labour earnings by selected sectors in the period 2005–2022, including predictions for the period 2022–2025, using Holt's linear exponential smoothing and integrated mixed ARIMA model, which were evaluated as the best fit based on interpolation criteria. The sample residual autocorrelation function, the sample residual partial autocorrelation function, the Durbin-Watson statistic and extrapolation criteria, such as Theil's mismatch coefficient, were used to verify the suitability of the models.

Time series of nominal average gross monthly labour income from work were converted to time series of real average gross monthly labour income from work with a base in 2005, including predictions for the period 2023–2025, using chain consumer price indices representing the annual rate of inflation. Predictions of chain indices of consumer prices for the period 2023–2025 were also constructed using an autoregressive model, see Figure 10.

Figures 1–10 show only the investigated time series models and give an idea about the accuracy of these models and the predictions constructed based on these models. However, this is only a tool, not the result of the analysis. For this reason, a more detailed interpretation of these figures loses its meaning.
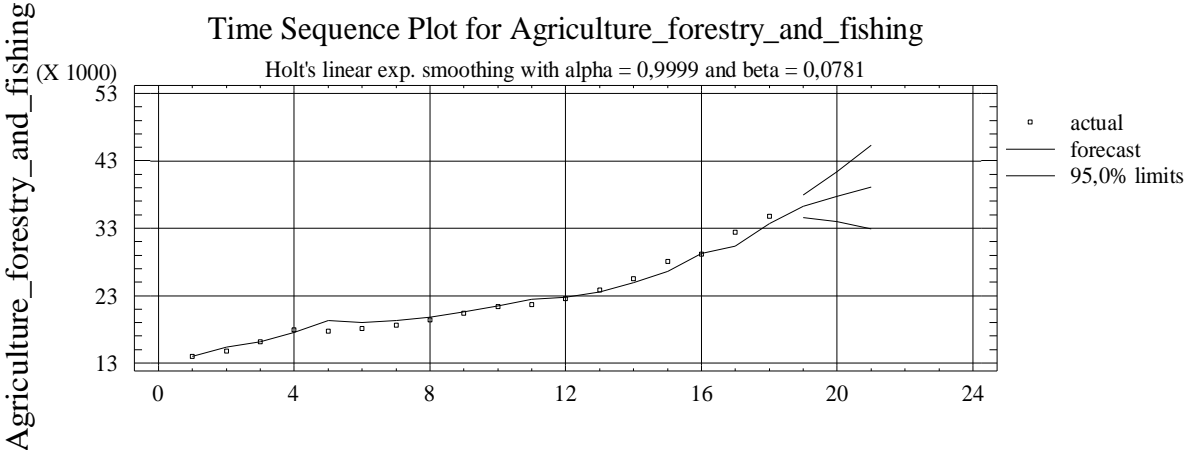
Figure 1. Holt's linear exponential smoothing of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Agriculture, Forestry and Fishing

Time Sequence Plot for Industry
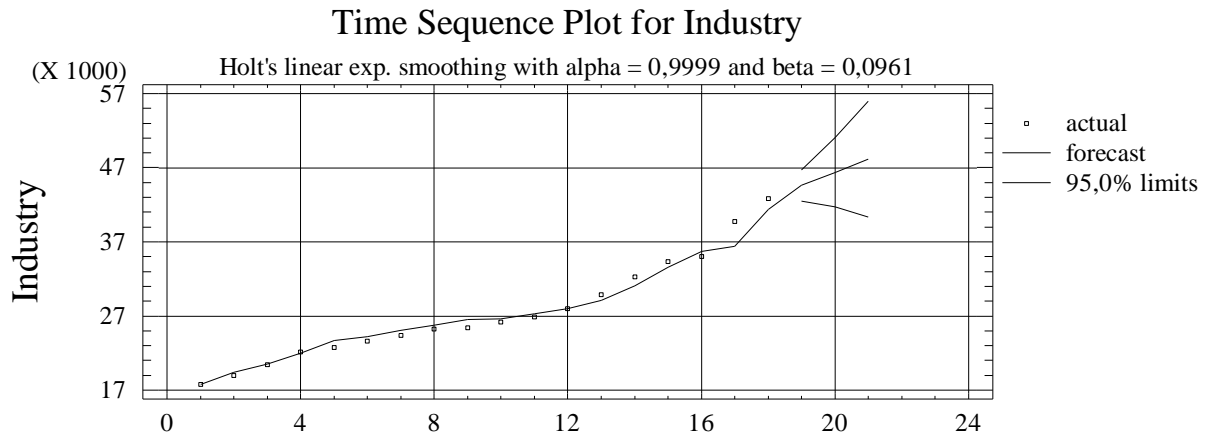
Figure 2. Holt's linear exponential smoothing of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Industry

Time Sequence Plot for Construction
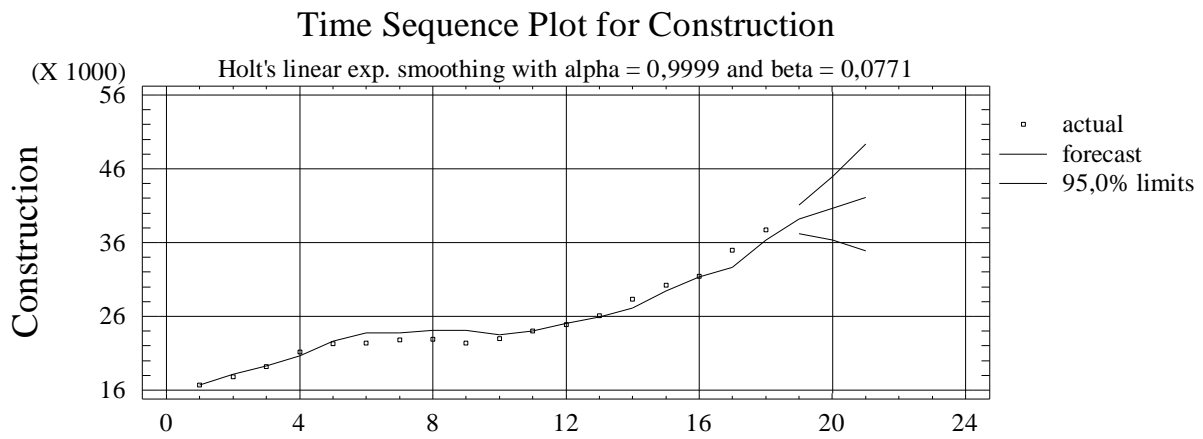
Figure 3. Holt's linear exponential smoothing of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Construction

Time Sequence Plot for Information_and_communication
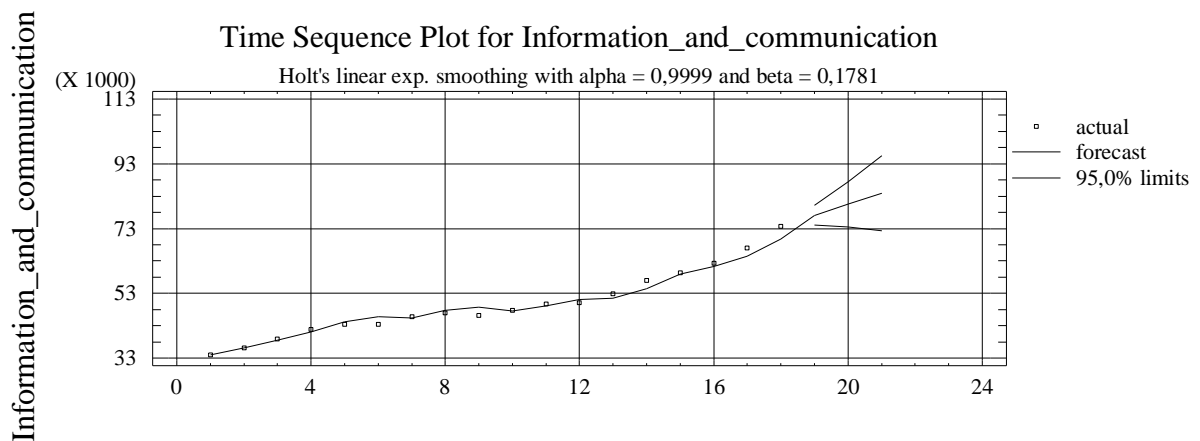
Figure 4. Holt's linear exponential smoothing of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Information and Communication

Time Sequence Plot for Financial_and_insurance

Holt's linear exp. smoothing with alpha = 0,387 and beta = 0,9999
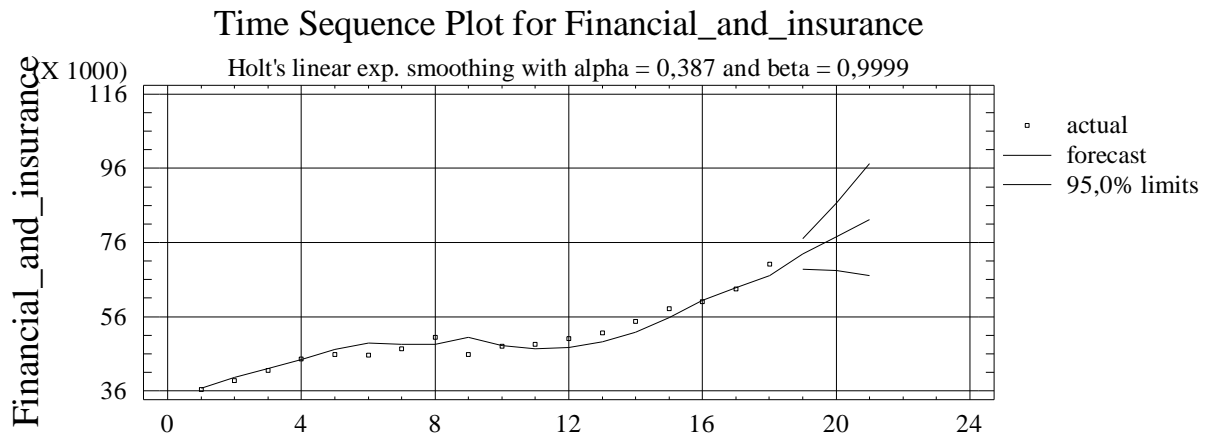
Figure 5. Holt's linear exponential smoothing of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Financial and Insurance Acrivities

Time Sequence Plot for Education

Holt's linear exp. smoothing with alpha = 0,9999 and beta = 0,0001
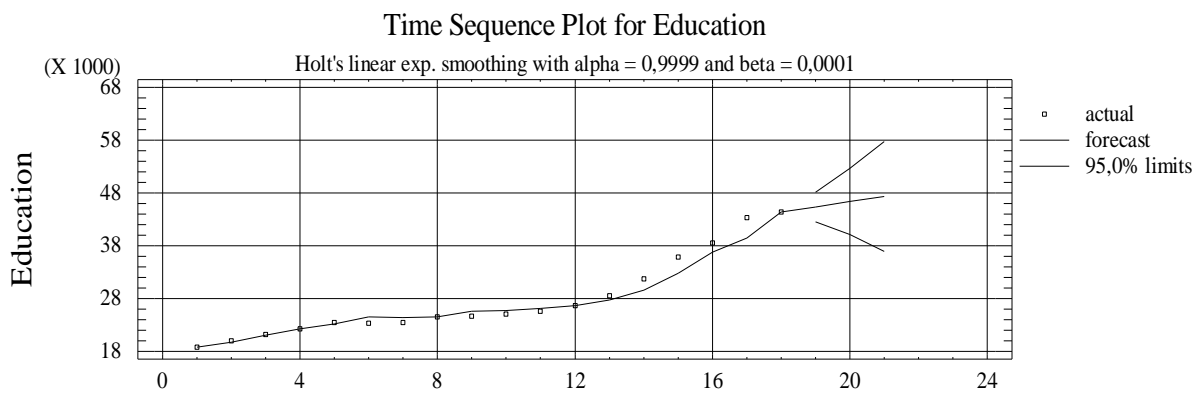
Figure 6. Holt's linear exponential smoothing of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Education

Time Sequence Plot for Human_health_and_social_work

ARIMA(1,0,0) with constant
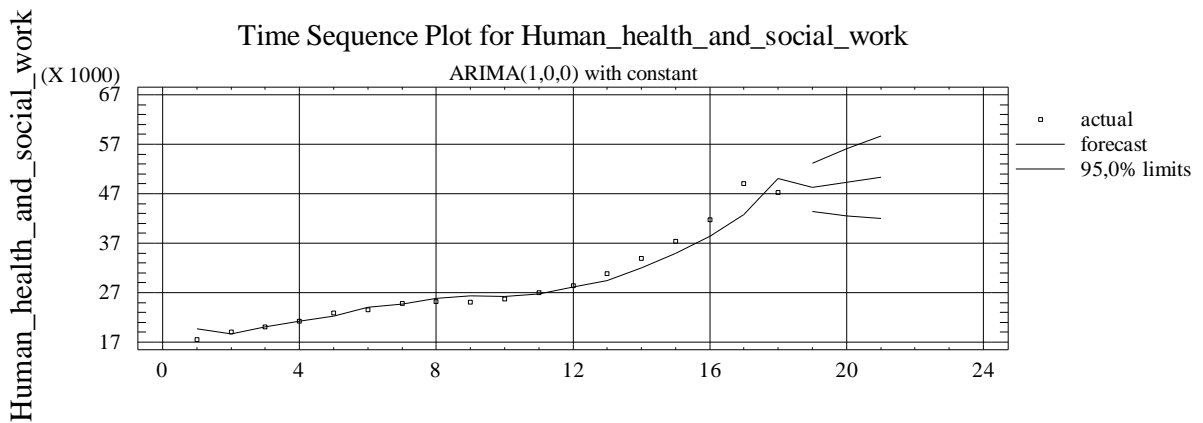
Figure 7. Holt's linear exponential smoothing of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Human Health and Social Work Activities
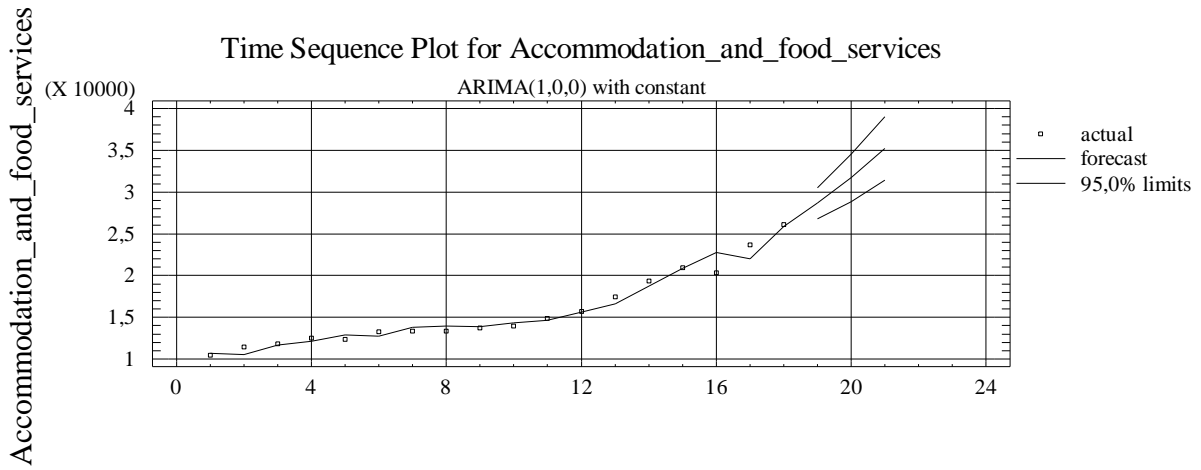
Figure 8. Holt's linear exponential smoothing of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Accommodation and Food Services
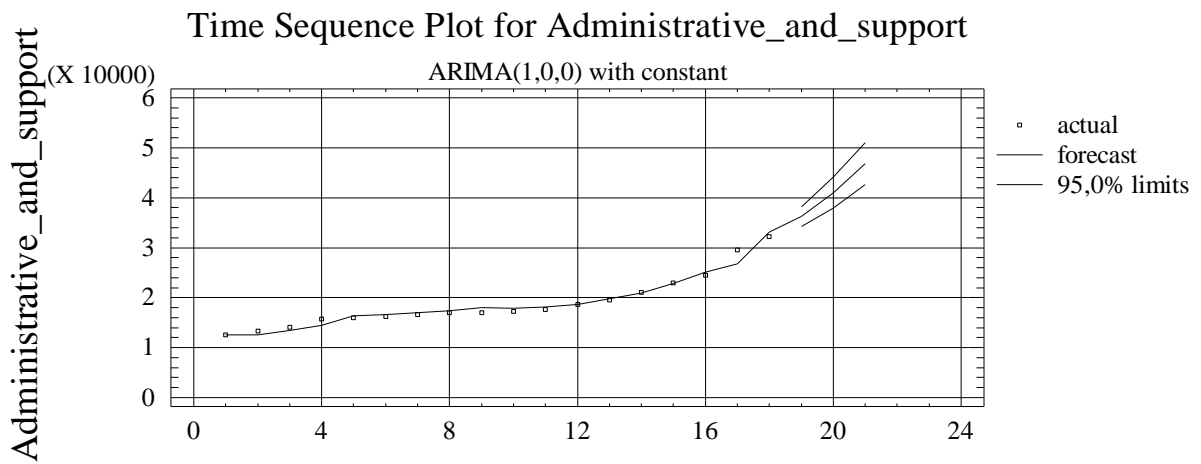
Figure 9. Model ARIMA of the time series of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 for the Sector of Administrative and Support Service Activities
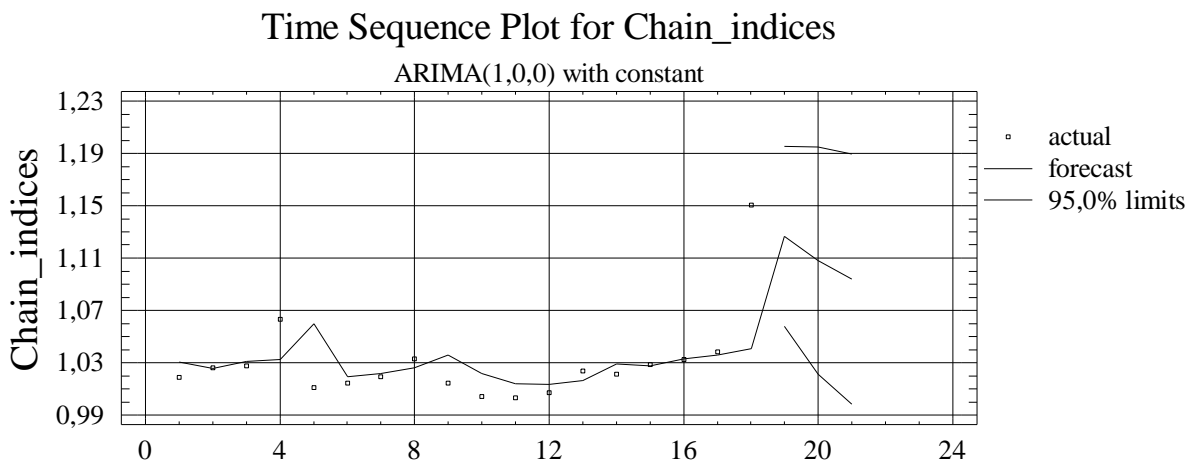
Figure 10. Model ARIMA of the time series of chain indices of consumer prices in the period 2005–2022, including predictions for the period 2023–2025 for the Czech Republic

3. Results

Figure 11 represents the development of the nominal average gross monthly income from work in the period 2005–2022, including predictions of this development for the period 2023–2025 by sectors, and Figure 12 represents the development of the real average gross monthly income from work in the period 2005–2022, including predictions of this developments for the period 2023–2025 by sectors.

Figure 13 shows the development of the growth rate of nominal average gross monthly income from work in the period 2005–2022, including predictions of this development for the period 2023–2025 by sectors, and Figure 14 shows the development of the growth rate of real average gross monthly income from work in the period 2005–2022 including predictions of this development for the period 2023–2025 by sectors.

Figures 11 and 13 show the steady growth of nominal average gross monthly earnings over the period of the crisis related to the COVID-19 pandemic and the subsequent energy crisis in all analyzed sectors, except for the Sector Accommodation and Food Service Activities, which was affected by the crisis related to the COVID-19 pandemic the most. Here we record a drop in nominal average gross monthly earnings by 3.21% in 2020, when the COVID-19 pandemic hit the Czech Republic in full.

Figures 12 and 14 show that the crisis related to the COVID-19 pandemic has negatively affected the real average gross monthly income for work, again mainly in the Sector of Accommodation and Food Service Activities, where we record a decrease of 6.24% in 2020. A slight decrease of this income in 2020 is also evident in the case of the Sector of Industry (by 1.18%) and the Sector of Financial and Insurance Activities (by only 0.7%). In 2021, the real average gross monthly income for work is already growing in all analyzed industries.

A much more serious situation in terms of real average gross monthly income for work occurs in connection with the energy crisis in 2022, when this income decreases in all analyzed sectors. Within the framework of the order from the worst situation, the highest decrease in the real average gross monthly income for work is recorded in the Sector of Human Health and Social Work Activities (even by 16.31%), then in the Sector of Education (by 11.08%), Sector of Agriculture, Forestry and Fishing (by 6.56%), Sector of Construction (by 6.41%), Sector of Industry (by 6.34%), Sector of Administrative and Support Service Activities (by 5.33%), Sector of Information and Communication (by 4.45%), Sector of Accommodation and Food Service Activities (by 4.16%) and Sector of Financial and Insurance Activities, which was hit the least out of all analyzed sectors, where the real average gross monthly income for work decreased by 3.78%, see Figures 12 and 14.

It can be therefore stated that the crisis related to the COVID-19 pandemic had a significant negative impact on real labour income in the Sector of Accommodation and Food Service Activities. The negative impact of the energy crisis on the real average gross monthly income from work was much more pronounced than the impact of the global economic crisis that began in the fall of 2008.
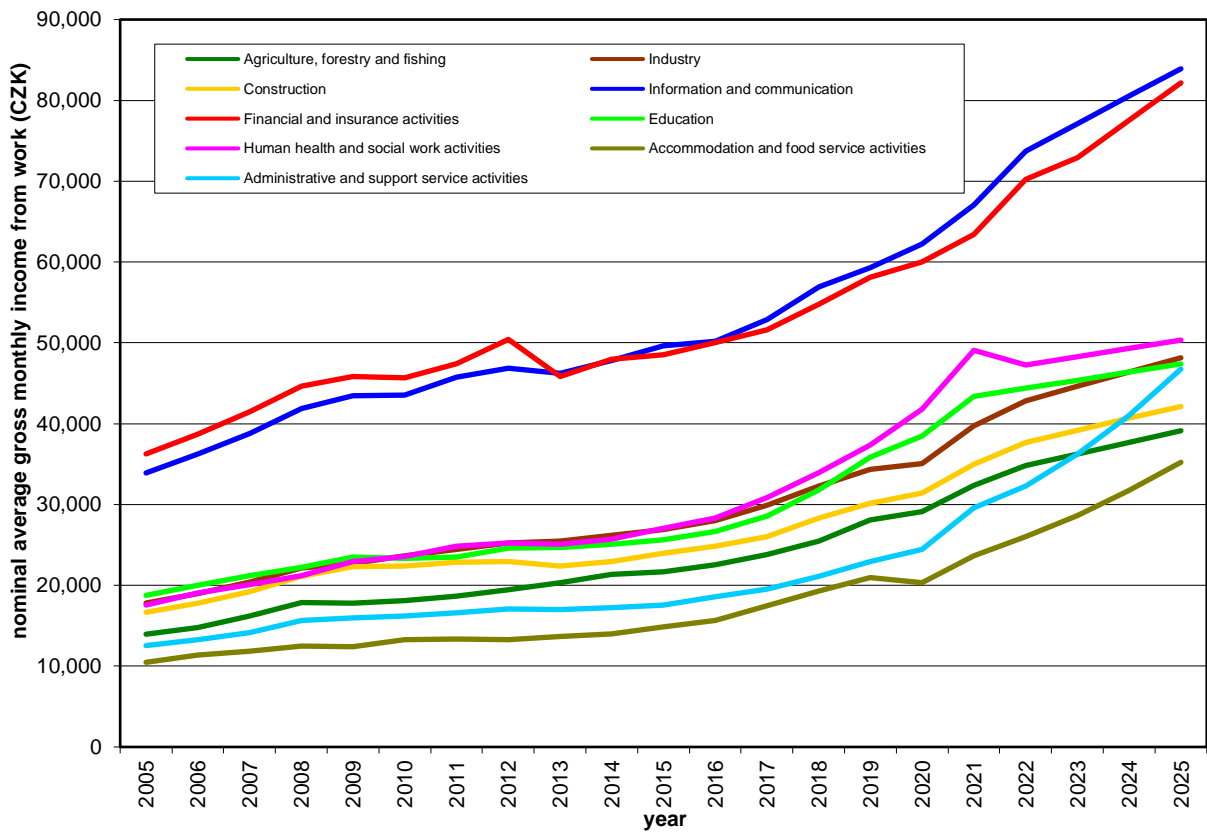
Figure 11. Development of the nominal average gross monthly income from work (CZK) in the period 2005–2022, including predictions for the period 2023–2025 according to selected sectors
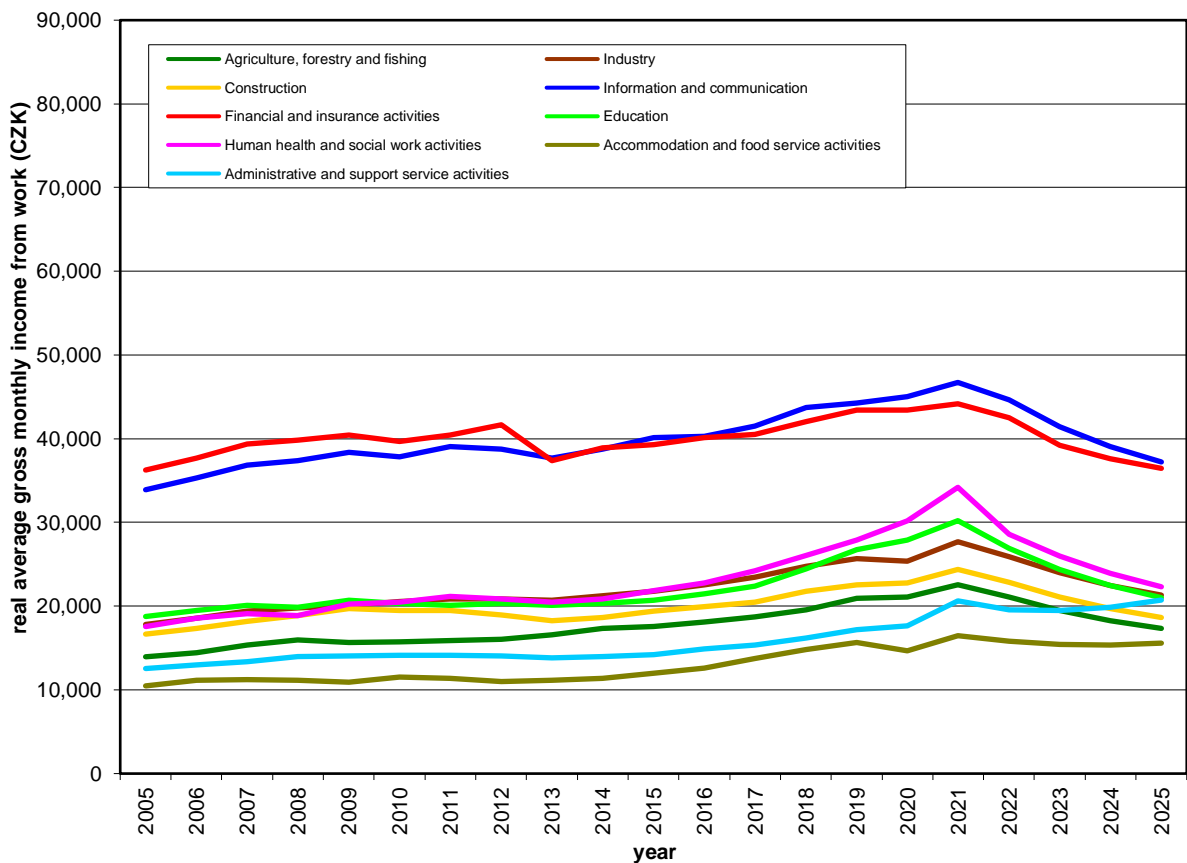
Figure 12. Development of the real average gross monthly income from work (CZK) in the period 2005–2022, including predictions for the period 2023–2025 according to selected sectors
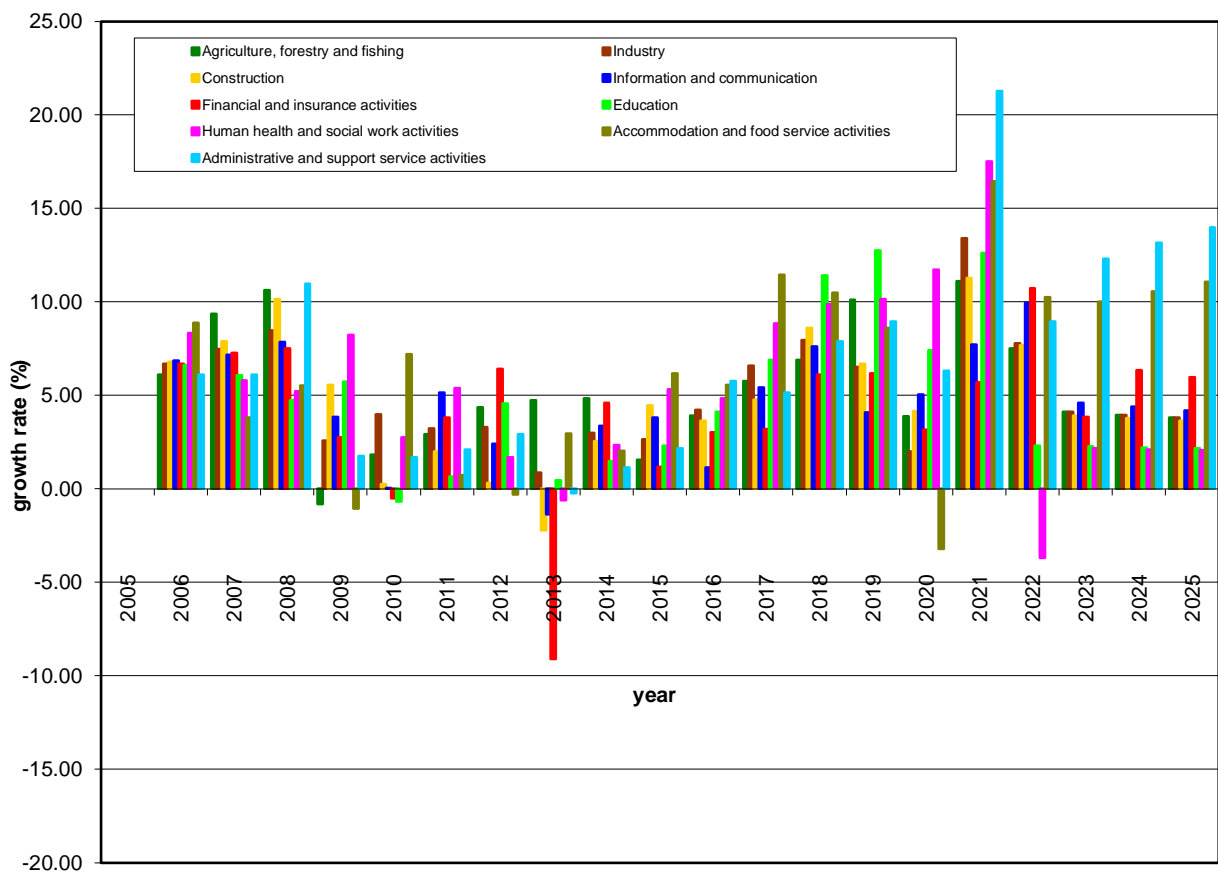
Figure 13. Development of the growth rate (%) of nominal average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 according to selected sectors
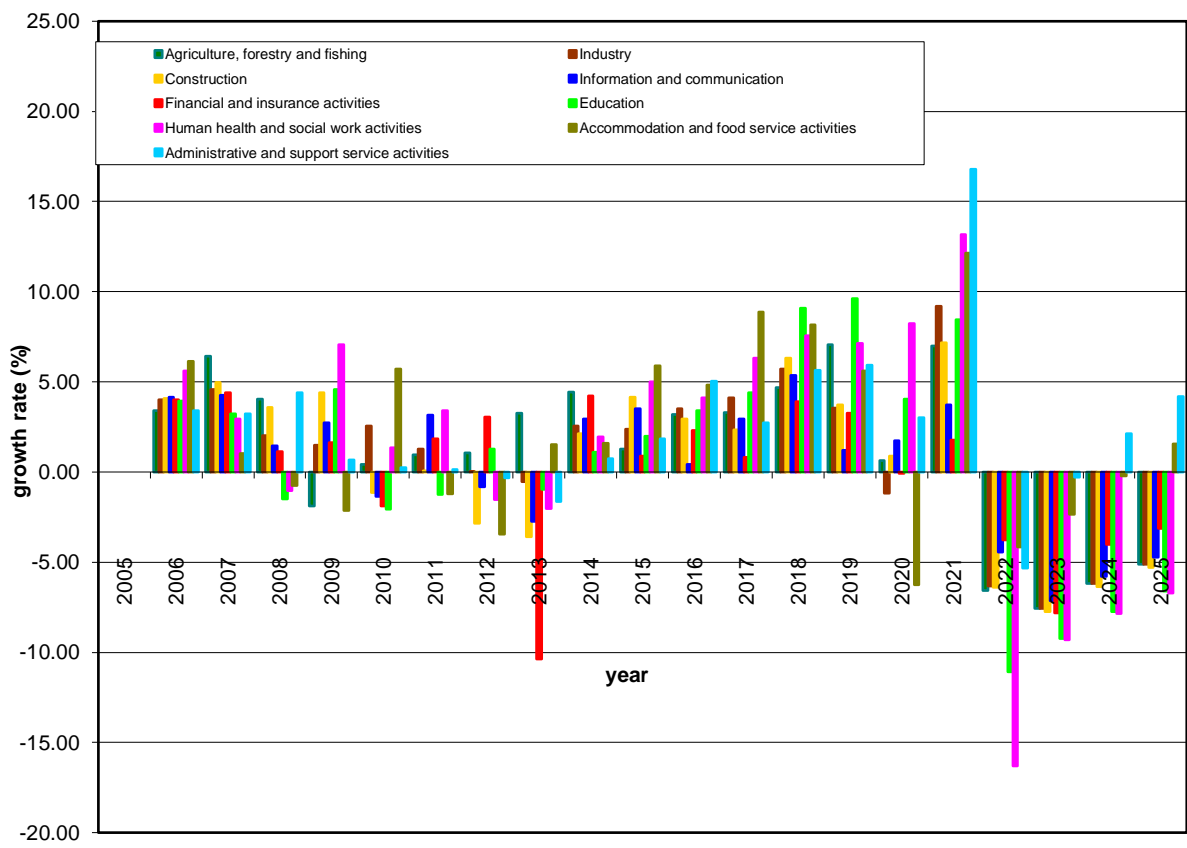
Figure 14. Development of the growth rate (%) of real average gross monthly income from work in the period 2005–2022, including predictions for the period 2023–2025 according to selected sectors

4. Discussion

The limitation of labour earnings is similarly captured by a study by Estupinan, Gupta, Sharma, and Birla (2020) which reveals an initial labour supply shock related to the lockdown measures taken by the Indian government to limit the spread of COVID-19. The author collective estimates the monthly loss of wages and incomes of workers at Rs. 864.5 billion in 2017–2018 prices. The heterogeneous effects of the Canadian economic shutdown due to the COVID-19 pandemic across earnings distributions are addressed in research by Koebel and Pohler (2020). Analyses of the labour market have revealed that workers at the bottom of the earnings distribution experienced a much greater reduction in hours worked than workers at the top of the earnings distribution, which is associated with a substantial reduction in the earnings of low-income workers. The effects of social distancing associated with COVID-19 have resulted in school closures. Psacharopoulos, Collis, Patrinos, and Vegas (2020) expect closures to reduce school attendance and lead to future revenue losses. The research results confirm the loss of marginal future earnings based on a four-month layoff, differentiated by highest educational attainment. The paper by Weber and Yilmaz (2023) focuses on reduced working hours in the period of COVID-19 and labour income replacements that led to the stabilization of employment in Germany. The study presents a collective wage subsidy tool that increases with the loss of labour income or hours worked. The impact of the energy crisis exacerbated by the Russian-Ukrainian war on the general macroeconomic performance and income distribution of the Eurozone is addressed by the pair of authors Lampa and Oro (2023), who estimate the long-term consequences of sanctions and political strategies on global markets.

The development of nominal and real earnings during the period of the COVID-19 pandemic was significantly influenced by factors such as government interventions during the COVID-19 pandemic. The Czech government introduced the ANTIVIRUS program, the measures of which helped companies with the financial impact of the COVID-19 pandemic on their business and thus prevented massive layoffs. In the Sector of Accommodation and Food Service Activities, the impact of the COVID-19 pandemic could be significant, as most establishments were unable to operate, employees were laid off, which could have also an impact on the development of income in this sector. This development could be also related to a significant increase in income in the following period, when employment in this sector increased and the demand for new employees instead of those previously laid off.

Similarly, in the period of the energy crisis, when we recorded growth in nominal earnings in most sectors, however, as a result of strong inflation, the real earnings of employees fell fundamentally. This phenomenon was caused by insufficient government support measures compared to the COVID-19 pandemic.

5. Conclusions

The paper analyzed the comparison of the negative impacts of the energy crisis of 2022, COVID-19 pandemic crisis of 2020 and the global economic crisis of 2008 on the level of real income from work in selected sectors of the Czech economy.

It was found that the crisis related to the COVID-19 pandemic significantly negatively affected the level of real labour income only in the Sector of Accommodation and Food Service Activities, but the level of this real income increased significantly in the following year. The negative effects of the 2022 energy crisis on real labour income significantly affected all sectors analyzed, and these effects were significantly harsher than the effects of the 2008 global economic crisis, which were also more diluted over time in addition.

The limitation of this research can be seen in the availability of data that was taken from the official website of the Czech Statistical Office. There are therefore secondary aggregated data and not primary individual data. The length of the examined time series caused by the change in the methodology of the Czech Statistical Office is also a certain inconvenience.

From the point of view of future research, it is possible to analyze all sectors of the Czech economy in a similar way. It is also possible to focus on work professions.

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Trends and Prospects for Tourism Development in EU Countries

Tetiana BUT

University of Hradec Kralove, Hradec Kralove, Czech Republic; tetiana.but@uhk.cz

Abstract: The purpose of the study is to identify trends and prospects for tourism development in the European Union (EU). It has been established that tourism in the EU is recovering rapidly after COVID-19 due to high consumer demand. According to the results of the analysis, it is noted that tourism is a key sector of economic growth and a driver of job creation in the EU due to an increase in the number of jobs in tourism, an increase in the payment of wages, and the level of GDP. Measures to improve the welfare of the population through tourism are investigated. Promising directions for the development of tourism in the EU are proposed, including: support for people with disabilities, youth; preservation of cultural and natural heritage; increase of EU membership; harmonization of quality standards; and assignment to the European Commission of the responsibility to create an appropriate space for the activities of all those interested in the field of air transport. The results of the study made it possible to formulate recommendations on the prospects for tourism development in the EU, which will strengthen the euro against the US dollar, increase the competitiveness of Europe's tourist attractiveness in the world and contribute to GDP growth and the welfare of the EU population.

Keywords: tourism; EU; development; prospects; economy; forecast; inflation

JEL Classification: Z32; O52

1. Introduction

The purpose of the study is to identify trends and prospects for tourism development in the European Union (EU). The EU economy is focused on the social and environmental well-being of countries. Tourism is a popular type of economy that influences the economic development of countries and is a budget-forming industry. The importance of institutional factors such as low corruption, political freedom and intellectual property play a positive role in the development of EU countries and have a positive impact on the development of tourism in Europe compared to non-EU countries. Improving the environment has a positive impact on tourism revenues. This is due to the promotion of innovative practices in the field of circular economy in the areas of ecosystems, management and sustainable tourism. Today, a significant role in the development of tourism in the EU countries is played by the ever-increasing GDP per capita, which has been growing over the past decades, and the experience gained in overcoming the COVID-19 pandemic crisis. Furthermore, the development of tourism in the EU depends on the economy of the EU countries, which in turn depends on public administration, economic structures, business management, and other micro and macroeconomic indicators. The existing negative problems of the EU economy, such as the

shadow economy, loss of wealth due to income inequality, the financial crisis due to the war in Ukraine, inflation, and the slow development of digital technologies in the tourism industry, necessitate a more detailed study of the trends and prospects for tourism development in the EU.

2. Theoretical Part

Researchers Misini and Tosuni (2023) investigated which EU countries were most affected by COVID-19 and what economic consequences 27 European countries received from 2000 to 2020. The researchers also studied the impact of Russia's invasion of Ukraine on EU countries. It was found that the countries most affected by COVID-19 are those that depend on tourism. And Hungary, the Czech Republic and the Republic of Ireland were recognized as the most affected by Russia's invasion of Ukraine. In particular, this approach does not examine the impact of the pandemic on European welfare, nor does it determine the forecast values of tourism development in the EU in the future.

Grané et al. (2021) in their study identified the socio-demographic impact of the population in 28 European countries on European well-being after the COVID-19 pandemic. Scientists have proved the need for public policy to be differentiated and the need for governments to develop action plans to improve the physical and mental health of vulnerable populations. This approach points to the fight against poverty and state support for economically inactive segments of the population (retirement age) due to their financial difficulties. The scope of research in this aspect requires studying the impact of the COVID-19 pandemic on different age groups and supporting their well-being through tourism.

Researchers Shkolnykova et al. (2024) identified the factors that influence the economy in Central and Eastern Europe based on a clear distinction between EU and non-EU countries. This study identifies the importance of the impact of institutional variables on economic development in Central and Eastern Europe, thus leaving out Southern, Western and Northern Europe and how tourism affects the development of the European economy.

Erdiaw-Kwasie et al. (2023) studied tourism revenues in Europe. The researchers proved that tourism revenues are increasing due to the improvement of the quality of the ecosystem in EU countries and the increase in innovative components. The study was conducted for the period from 2000-2020 and requires the identification of further practical proposals for the development of tourism in the post-COVID-19 period.

Sánchez-Bayón et al. (2023) identified changes in the economies of EU countries due to failures in the management of the tourism sector, whose economic structure is not adapted to the digital transition. Researchers have identified improvements in the European economy due to digital technologies. Therefore, this approach emphasizes the restructuring of the tourism sector due to the impact of digital technologies, but there is a need to take into account the environmental component and the relationship between the EU governments and the population in this process.

Van der Slycken and Bleys (2024) identified the gap between wealth in Europe and GDP, due to the financial crisis and income inequality. The fact that the welfare of the population in 9 EU countries is declining indicates a focus on social and environmental well-being. Such

an approach requires exploring how tourism can have a positive impact on both improving the EU's GDP per capita and increasing the income of the population.

3. Methodology

The theoretical basis of the study is the fundamental works of scientists on the development of tourism in the EU, its evaluation, identification of problems and factors influencing its development. The following special methods were used in the study: structural and logical analysis (for the logical structural construction of the work and the formation of conclusions); generalization and systematization (to systematize the views of scientists, to identify approaches to identifying trends in the development of tourism in the EU); analysis and synthesis (to determine the peculiarities of digitalization in tourism, forecast values of tourism development in the EU, factors influencing tourism development); graphic representation (for analyzing the main trends and prospects of tourism development in the EU, visual representation of statistical materials and analytical data); comparison (to analyze tourism development before, during and after COVID-2019 and its consequences).

To determine the trends and prospects of tourism development in the EU countries, the following indicators were analyzed: the number of nights spent in accommodation facilities; the number of people employed in tourism; wage levels in the EU; GDP growth and its contribution to the travel and tourism sector; the number of employees by business size class in accommodation and catering establishments; the current state of inflation in tourism; and expected forecast growth in tourism based on GTS data; measures to support tourism development in the EU. The research was supported by the following documentation: UNWTO, Eurostat Statistics Explained, European Commission, European Parliament, European Innovation Scoreboard, Statistisches Bundesamt, and World Travel & Tourism Council.

4. Results

Summarizing the above, the study will determine: how tourism has developed in the EU after COVID-2019 and its current state; how tourism is improving European welfare; what factors have a positive impact on economic development in Europe due to tourism; how digitalization affects tourism, taking into account the environmental component and governing bodies; what measures can be taken to improve the welfare of the EU population through tourism and, as a result, what are the prospects for tourism development in the EU today.

Let us examine the short-term dynamics of the number of overnight stays in tourist accommodation facilities in the European Union (EU) with a comparison of data for the same period of the previous year, as shown in Figure 1.

These dynamics have been followed by a sharp decline in tourism during the COVID-19 pandemic since 2019 and throughout 2020. The analysis showed a steady growth in tourism over the study period, starting in 2008 until the start of the pandemic, after which the number of nights spent decreased in the EU and globally.
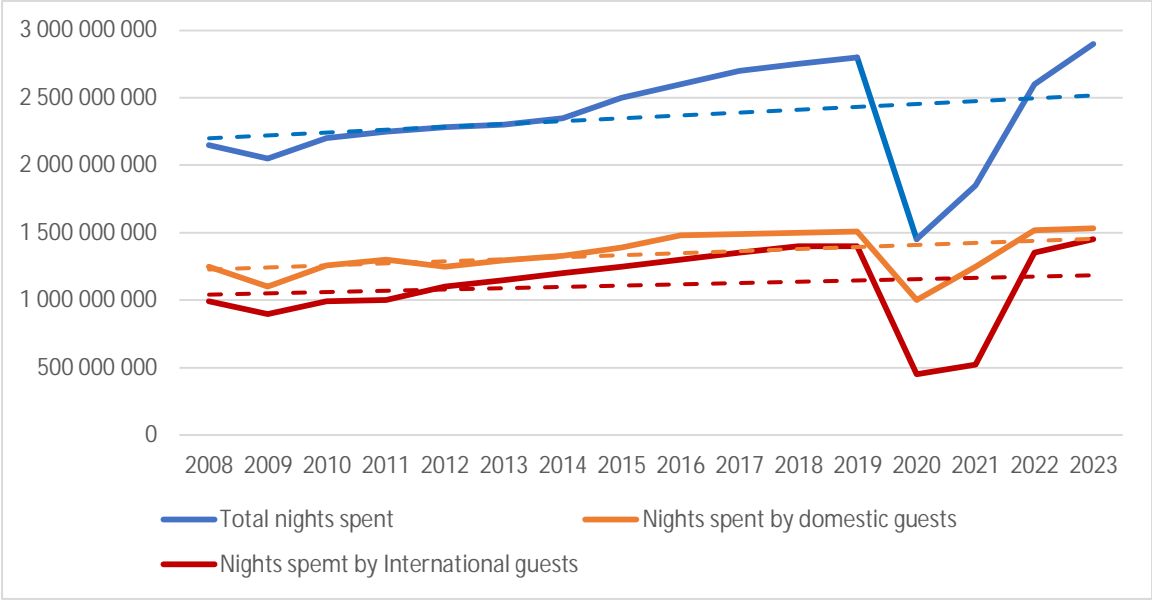
Figure 1. Annual estimates – Number of nights spent in tourist accommodation establishments, EU, 2008-2023 (Eurostat, 2024c)

Tourism has ceased its operations and gained new experience in overcoming the crisis due to the COVID-19 pandemic. Thus, the positive dynamics of tourism recovery in the EU countries have been observed since the beginning of 2021 and during 2022-2023, and the data for 2023 have already exceeded the figures for 2019.

The next indicator is developments in the tourist accommodation sector in the European Union. Figure 2 shows that the total number of international nights in the EU in 2022 was 1.2 billion (Eurostat, 2024c).
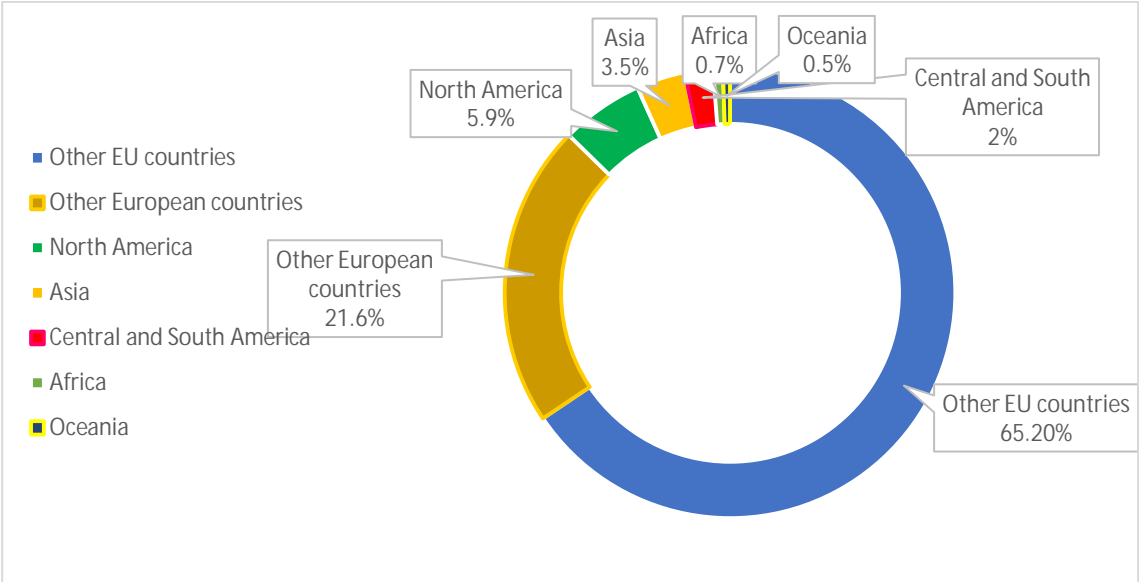
Figure 2. Nights spent by international guests in tourist accommodation in the world and the EU in 2022 (Eurostat, 2024c)

The results of Figure 2 show that among the countries of the world, Europe has the largest number of international nights. This indicates the high tourism potential in EU countries and the high interest of tourists in long-term travel. In 2022, there was a return of

international tourists traveling to the EU, with expenditure by foreign tourists increasing by 81% compared to 2021 and reaching almost €385 billion. Spending by domestic tourists fully recovered in 2022, surpassing the pre-pandemic high of €809 billion and reaching €814 billion (Eurostat, 2024a). Tourism is growing rapidly in Germany, Italy, Spain and France. Paris remains the most popular tourist destination in the world (Eurostat, 2024a).

After growing steadily between 2009 and 2019, tourism in the EU has become one of the sectors most affected by the COVID-19 pandemic from 2019-2020. The number of nights spent in EU tourist hotels in 2020 was halved compared to 2019. 2021 showed clear signs of recovery, reaching almost two-thirds of the 2019 level. The upward trend continued in 2022, when it reached 96%, while short-term indicators for monthly data showed that the number of nights spent in the first six months of 2023 exceeded the pre-pandemic level of the first six months of 2019 (Eurostat, 2024c). This figure also confirms the recovery of tourism in the EU after COVID-19.

The next indicator - the share of the population employed in tourism in 2022 by EU countries – is shown in Figure 3.
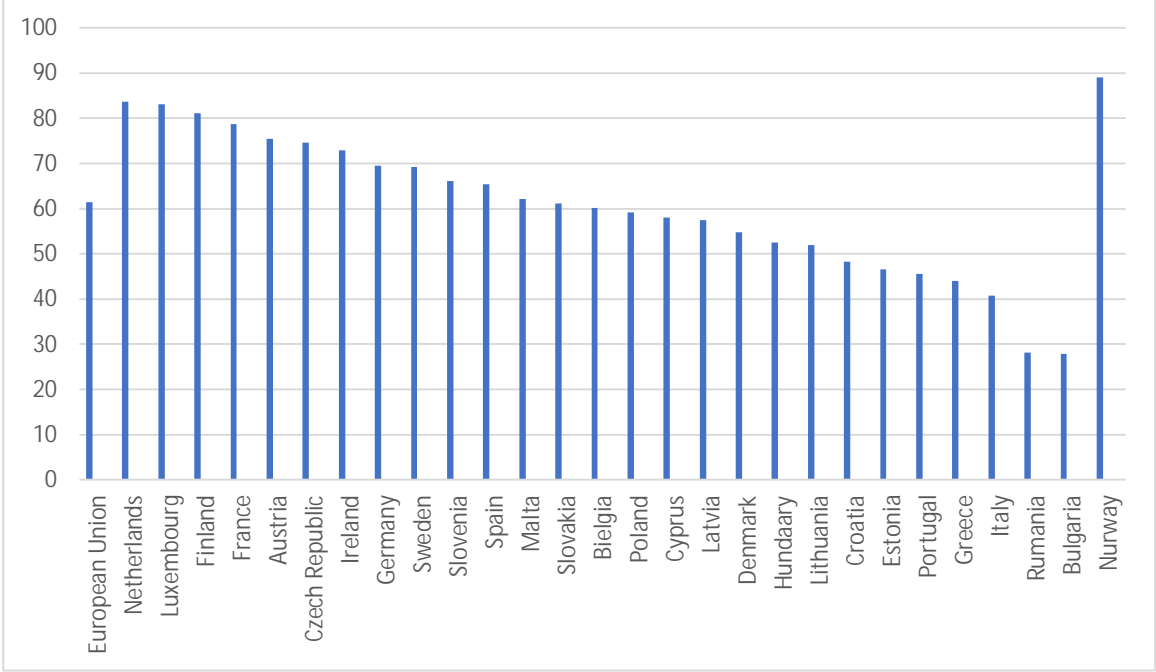
Figure 3. Share of population EU participating in tourism, 2022 (Eurostat, 2024c)

The data on tourism statistics in the European Union identify the leading countries that are developing tourism the most. Among them, the top five are Norway, the Netherlands, Luxembourg, Finland, and France. Tourism plays an important role in the EU by increasing the economic potential of countries, and employment, and has positive social and environmental impacts. In 2022, the tourism sector also created 2 million more jobs compared to 2021, reaching 21.8 million jobs - one in ten jobs in the EU. According to the World Tourism Organization, the tourism sector has recovered 3.1 million of the 3.6 million jobs lost during the pandemic (WTTC, 2023). The World Travel and Tourism Council (WTTC) predicted that in 2023, the tourism sector will create more than 687,000 jobs, recovering almost 90% of the jobs lost due to the COVID-19 pandemic, and reach more than 22.4 million, with one in nine

EU workers working in the travel and tourism sector (Eurostat, 2024a). The positive dynamics of growth in the number of people employed in tourism also indicates a recovery in tourism after COVID-19, the growth of tourism and the improvement of the population's well-being by reducing unemployment.

The next indicator is the hourly wage in the EU, which in 2022 increased by 4.4% across all sectors of the economy. In 2022, wages in the EU increased by +4.5% in the service sector, compared to 2021, and its hourly wage increased by +5.0%. (Eurostat, 2024 a). According to the average annual salary in the EU in 2022, it is possible to monitor not only EU tourism policy, but also regional and sustainable development policy.

Thus, in terms of the level of wages in tourism, it can be noted that the welfare of the population in the European Union is growing, increasing the standard of living of the population.

The next indicator is the contribution of the travel and tourism sector to GDP, which grew by 40.5% in 2022 to more than €1.37 trillion, accounting for 8.7% of the EU economy, approaching the record high of 9.6% of the economy in 2019.

Data on employment in the accommodation and catering sector in the EU are shown in Figure 4.
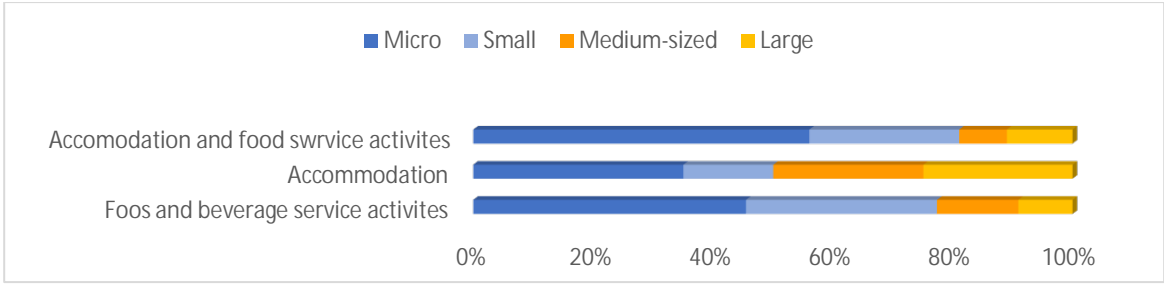
Figure 4. Sectoral analysis of employment by enterprise size class, accommodation and catering activities, EU, 2020 (% share of sectoral employment) (Eurostat, 2024d)

As you can see, we have presented an overview of statistics for the accommodation and food services sector in the European Union (EU) for 2020. It should be noted that these activities make up a significant part of the tourism offer, although they also serve local customers and business clients. 9.1 million people across the EU work in hotels and restaurants (Statistisches Bundesamt, 2024).

Examining European inflationary processes, we note that inflation in the European Union fell to 6.1% in 2023. Analysts point out that the decline in inflation is positive, especially as the disinflationary process has consolidated and expanded in all major price categories, including core inflation. However, core inflation is likely to decline only at a very moderate pace, given the strength of price pressures in the services sector. However, it is clear that inflation in the European Union has already peaked. Forecasts point to a gradual decline in inflation in the coming quarters, with expectations that it will average 5.3% across the euro area this year (ETC, 2024). Inflation in the service sector is returning to its previous level due to lower prices for some goods, but labor-intensive sectors are still experiencing growth. Positive currency movements against the euro in Q2 2023 were observed in the following

countries: Hungary (25.9%), the Czech Republic (15.3%), Bulgaria (10.6%), Poland (13.3%), Romania (11.0%), and Denmark (4.2%) (ETC, 2024).

As you can see, based on many years of experience, tourism maintains Europe's reputation as a leading economic growth destination. Although inflationary pressures have eased, we believe that the EU economy is not yet sustainable. Therefore, we note that there may be a temporary inflationary imbalance due to such negative factors as energy dependence and the war in Ukraine.

The forecasts for tourism in the European Union are based on GTS data. These are the results of the Global Travel Service (GTS) model, which is updated in detail three times a year. The forecasts are in line with the Oxford Economics macroeconomic forecast in accordance with the assumed relationship between tourism and the economy as a whole (Table 1).

Table 1. Visitor Growth Forecasts, % change year GTS (ETC, 2023)*

	Inbound					Outbound				
	2021	2022	2023	2024	2025	2021	2022	2023	2024	2025
Europe	10.9%	108.7%	28.4%	17.2%	13.5%	9.4%	111.6%	28.9%	17.2%	13.4%
ETC+2	24.0%	96.1%	13.2%	11.9%	10.5%	19.8%	101.3%	15.5%	11.8%	10.1%
EU 27	20.0%	106.0%	12.9%	10.9%	9.4%	17.3%	110.1%	14.1%	10.5%	9.3%
Non-EU	14.2%	112.7%	12.7%	10.8%	9.1%	16.0%	114.1%	14.5%	10.4%	9.0%
World	69.3%	44.1%	15.6%	16.8%	16.2%	36.8%	52.3%	20.9%	18.9%	14.9%

* Tourism Economics based on GTS as of 25.06.2023

The GFS forecasts for visitor arrivals include: an inbound figure based on the sum of overnight tourist arrivals per country and including intra-regional flows; an outbound figure based on the sum of visits to all destinations. The geography of Europe was defined as follows: Northern Europe is Denmark, Finland, Iceland, Ireland, Norway, Sweden and the United Kingdom; Western Europe is Austria, Belgium, France, Germany, Luxembourg, the Netherlands and Switzerland; Central and Baltic Europe is Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania and Slovakia; ETC+2 is all ETC members plus Sweden and the United Kingdom.

The growth in forecast values is driven by high demand from visitors who are willing to pay for expensive holidays. However, there is concern about overcrowding of travelers. As a result, tourism organizations have launched campaigns to ensure an even distribution by raising the prices of entrance tickets to tourist attractions, as tourists will not necessarily spend money on entry. This increase in visitor arrivals does not bring a proportionate economic benefit. In our view, such a scheme is crucial for tourism to remain socially sustainable for Europe's most popular destinations.

As we can see, EU policy aims to maintain Europe's reputation as a leading destination, while maximizing the industry's contribution to economic growth and employment and encouraging cooperation between EU countries, in particular through the exchange of best practices.

The World Tourism Organization predicts that by 2033, the sector's contribution to GDP will grow to almost €1.9 trillion, representing more than 10% of the EU economy, and employing more than 26.3 million people across the region, with one in eight EU residents

Table 2. Measures to support tourism in EU countries (European Parliament, 2024)

Title.	Measures to support tourism in the EU
1. Activities that benefit tourists (travelers and/or holidaymakers)	Facilitating border crossing and protecting both the health and safety and material interests of tourists. They include Council Recommendation 86/666/EEC on fire safety in hotels, Directive 2008/122/EC on timeshare properties and Directive (EU) 2015/2302 on package travel. Rules on passenger rights in all areas of transport have been adopted.
	At the request of the Parliament, the Commission has taken initiatives in the form of five preparatory programs on targeted topical issues of European tourism.
	The «Eden» Initiative aims to promote Europe's 'great destinations', in other words, little-known and emerging destinations that are sustainable.
	The concept of "sustainable tourism" includes a "European Green Belt" (6,800 km of routes from the Barents Sea to the Black Sea), which aims to promote the transformation of the former Iron Curtain into a cross-border network of hiking and cycling trails. The EU also co-finances cross-border sustainable tourism projects to diversify tourism opportunities in Europe.
	The «DiscoverEU» program, among several other tourism promotion programs, allows 18-year-old Europeans to travel around the EU and learn more about the diversity of Europe.
2. Responsible tourism measures that benefit the tourism industry and regions	The Commission supports the creation of networks between the main European tourism regions. The EU offers a range of funding sources to help tourism contribute to regional development and employment.
	In April 2022, the Commission adopted a proposal to establish a pan-European system for the protection of geographical indications for non-agricultural products. These products are often important for local identity and tourist attraction. One of the objectives of the revised regulation is to stimulate regional economies and tourism in these areas.
	Harmonized tourism statistics have been collected in the EU since 1996. In October 2022, the Commission launched the EU Tourism Dashboard, a tool to help regional and national decision-makers guide policies and strategies in the tourism sector by increasing the availability of tourism statistics and assisting destinations and public institutions in monitoring their progress in the transition to green and digital.
	In November 2022, the Commission adopted a revised Regulation (EU) 2018/1724 on the collection and exchange of data relating to short-term rental services, with a particular focus on small and medium-sized enterprises. This initiative aims to promote responsible, transparent and fair growth of short-term rentals as part of a well-balanced tourism ecosystem.
3. Other events	The Commission holds a demonstration conference on tourism and plans to repeat them systematically.
	In 2023, the Commission adopted a regulation on the digitalization of travel documents. This has made travel easier as digital travel documents are easier to issue, which would benefit the tourism industry.

working in the sector (WTTC, 2023). In our opinion, such promising forecasts will have a positive impact on economic development and tourism in the European Union.

A study of tourism support measures in EU countries is presented in Table 2 (see below).

Since December 2009, the EU has been empowered to implement measures aimed at supporting, coordinating or complementing the actions of Member States in the field of tourism policy. Although the 2021-2027 Multiannual Financial Framework does not include a separate budget line for tourism policy, a budget for tourism activities was provided for in the Single Market Program during 2022-2023.

Measures to support tourism in EU countries include: measures that benefit tourists; responsible tourism measures that benefit the tourism industry and regions; and other targeted measures.

These measures are aimed at improving the well-being of the population through tourism, facilitating tourist travel and ensuring their safety and comfort in accordance with international quality requirements, and supporting vulnerable populations through financial and spa vouchers for rehabilitation; through digital technologies in tourism to reduce energy consumption, manage and reduce fuel costs, use mobile applications and camera systems; improve the environmental safety of society; create platforms with information on popular places to visit; create independent tourist routes and independent public transport for tourists; and promote trust between the public and authorities (But, 2023).

Based on the trends examined, we propose the following challenges for European tourism in the EU in the future:

- transport development and improvement in line with tourist flows and routes,
- environmental protection,
- creating adequate quality of tourism services; creating and effectively using the latest information and communication technologies as a key factor for maintaining competitiveness; improving working conditions and creating new jobs.

In our view, it is important that, following EU enlargement, the strategies used to implement EU tourism policy are similarly applied in the European Economic Area and in the candidate countries. These countries should be involved in the implementation of these policies and related measures and should support the development and dissemination of the evaluation methods and tools (quality indicators and benchmarks) necessary to properly monitor the quality of tourist destinations and services.

To this end, we propose a number of factors that will influence the future development of tourism policy in the EU:

- Development of the latest technologies that will facilitate the development of e-tourism services, which in turn will facilitate access to these services for a wider range of people through convenient online shopping and booking.
- Changes in the demographic structure of the population will lead to the development of new tourism products. Airfares are expected to fall, which will increase the number of such flights and make them more accessible to different population groups.

- The need for special routes and conditions for tourist routes for people with disabilities, who are also potential tourists and require certain favorable conditions, and for people over 60 years of age.
- Young tourists. Studies show that more than 20% of travelers to Europe are young people aged between 15 and 26, due to study trips.
- EU enlargement. The integration of the new Member States contributes to the development of tourism in the EU.

On the basis of the above analysis and taking into account the above challenges and factors, we propose the following promising areas for tourism development in the EU that will yield positive results:

- Persons with disabilities require special conditions and facilities.
- Young people need specific types of tourism services: safe travel, cultural experiences, youth exchanges, multicultural events, social and environmental activities, and training. in addition, young people need special accommodation, and have special transport and fare requirements.
- The challenge for tourism development in the new EU member states is to define the tourism sector on a professional basis and agree on quality standards;
- Preserving cultural and natural heritage as a key asset for tourism development in these countries.
- All airlines will have to provide consumer protection for their services in order to refund deposits (including taxes and surcharges) and repatriate consumers who have been harmed by the airline.
- The European Commission should be responsible for creating an appropriate space for all air transport stakeholders (airlines, airports and travel agents) to operate.

5. Discussion

Tourism is thus a major activity in the European Union, accounting for 10% of GDP and having a significant impact on the socio-economic development of the economy, reducing unemployment.

At the same time, tourism has the potential to contribute to environmental protection and poverty reduction. Tourism can also raise public awareness of the importance of environmental protection and involve as many people as possible in cooperation on environmental issues.

The study shows that after the end of COVID-19, tourism in the EU is set to recover from the beginning of 2021 and from 2022 to 2023. There has been some increase in the well-being of the European population due to tourism in the following indicators: growth in the number of jobs created, wage growth, GDP growth, and projected growth in tourism until 2025. Factors contributing positively to the economic development of Europe include the high tourism potential of EU countries, which increases the interest of tourists in long-term travel. Also, the recovery of tourism jobs lost during the pandemic and the reduction of inflation in the service sector. In order to identify ways to improve the well-being of the population in

the EU through tourism, the paper examines the existing tourism promotion measures of the European Union. Measures to support tourism in the EU include: measures that benefit tourists; measures for responsible tourism; measures that benefit the tourism industry and regions; and the introduction of digitalization to facilitate travel.

In our opinion, the proposed tasks, development factors, and promising directions of tourism development in the EU countries form the EU tourism policy. This approach is designed to promote employment and ensure the competitiveness of the European tourism market. We will define that tourism, relying on small and medium-sized enterprises, which are most suitable for adaptation and retraining in a market economy, will create a large number of jobs and increase the welfare of the EU population.

Further research will focus on determining the impact of innovative technologies on the development of tourism in Europe.

6. Conclusions

Thus, the trends and prospects for the development of tourism in the European Union are studied. It is established that tourism in the EU is recovering rapidly after COVID-19 due to high consumer demand. Tourism should be considered a key sector of economic growth and a driver of job creation in the EU due to the increase in the number of jobs in tourism, the increase in wages, and the level of GDP per capita.

Among the leaders of the EU countries are Germany, Italy, Spain, and France. Paris continues to be the most popular tourist destination in the world.

Among the measures to improve the welfare of the population through tourism are the following: financial support for vouchers to health resorts for vulnerable groups of the population; introduce digitalization in tourism to reduce energy consumption, manage and reduce fuel costs, use mobile applications and video surveillance systems; improve environmental safety for society; create platforms with information about popular places to visit; create separate public transport and tourist routes, and promote trust between the public and authorities.

The author proposes tasks, factors and promising directions for the development of tourism in the EU. Among the promising areas are: support for people with disabilities, youth; preservation of cultural and natural heritage; increase of EU membership; harmonization of quality standards; to entrust the European Commission with the responsibility of creating an appropriate space for the activities of all stakeholders in the air transport sector.

Thus, the study made it possible to formulate recommendations on the prospects for tourism development in the EU, which will strengthen the euro against the US dollar, increase the competitiveness of Europe's tourist attractiveness in the world and contribute to GDP growth and the welfare of the EU population.

Conflict of interest: none.

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Public Economics in the Context of Local Territorial Self-Government in Slovakia: A Study of Key Financial and Economic Aspects

Lukáš CÍBIK* and Martin ŠVIKRUHA

University of Ss. Cyril and Methodius, Trnava, Slovakia; lukas.cibik@ucm.sk; martin.svikruha@ucm.sk

* Corresponding author: lukas.cibik@ucm.sk

Abstract: This article explores the dynamics of public economy in Slovak local territorial self-government from 2010 to 2022, addressing regional variations and high-performing units based on population size. This study aims to contribute to a broader discussion on regional economic disparities and the impact of population size on the public economy of these entities. Analyzing ten indicators across 100 units, including towns and municipalities, revealed significant regional disparities. The Bratislava and Košice self-governing regions exhibited superior economic outcomes. Units with populations exceeding 20,000 consistently performed better, with the 25,000 to 53,000 range achieving the highest average economic performance. While positive outliers existed in smaller towns, larger urban centers proved more effective in public economy management. The findings call for nuanced analyses to enrich discussions on the role and status of cities in Slovakia.

Keywords: local territorial self-government; public economy; population; regional disparities; Slovakia

JEL Classification: H11; H72; R11

1. Introduction

Local territorial self-government systems form the foundation for community development, and a detailed examination of their economic aspects is crucial for informed decision-making. With local governments grappling with diverse challenges from fiscal responsibilities to service provision, a nuanced understanding of the economic landscape is key. The significance of this research stems from the need to comprehend the regional and population-driven dynamics influencing the economic well-being of these administrative units. This study seeks to contribute to a broader discussion on regional economic disparities and the impact of population size on the public economy of these entities.

A careful review of the existing research landscape reveals a growing interest in the economic dynamics of the local territorial self-government system. Key publications in this field emphasize the multi-level nature of economic indicators, the influence of regional affiliations, and the importance of population size in shaping the financial health of these entities. Notable works (Vartašova & Červená, 2017; Buček & Sopkuliak, 2016; Papcunová & Hudáková, 2021; Šamalík & Horváth, 2022; Butoracová Šindleryová et al., 2023) have paved the way for a deeper understanding of the challenges and opportunities faced by local self-governments.

While this study does not address specific outcomes, we anticipate that regional affiliations and population size will significantly impact the economic performance of the local territorial self-government system. The complex interaction of these factors is expected to reveal nuanced patterns contributing to our understanding of the broader economic landscape. We aim to support an interdisciplinary approach and encourage a wider discussion on the economic aspects of local self-governance, which is essential two decades after fiscal decentralization in Slovakia.

2. Methodology

The main goal of our research is to analyze the public economy in the conditions of local territorial self-government in Slovakia from 2010. In fulfilling the main goal, the research intent was decomposed, and two research questions were formulated:

- *Research Question 1:* Are there regional disparities in the economies of selected units of local territorial self-government across Slovakia?
- *Research Question 2:* Which population-large units of local territorial self-government achieve the most comprehensive average level of public economy?

The research design is structured around the examination of ten economic and financial indicators: Total debt, Debt service, Current account balance, Liabilities overdue in relation to current income, Liabilities unpaid 60 days or more overdue in relation to current income, Basic balance, Investment intensity, Net assets, Immediate liquidity, and Quick liquidity. These indicators, as relative cross-sectional metrics of financial health, were initially assessed during the period 2010-2022. Subsequently, a mathematical operation was employed to determine the average values (secondary data) over the observed period, serving as comparative and summative data for selected size groups and sets of units of local territorial self-governance categorized based on their regional affiliations.

The research scope encompasses 100 units of local territorial self-governance in Slovakia. The specific sample comprises 79 towns, 18 urban parts, two city districts, and the most populous municipality in Slovakia, Smižany. This selection represents a cross-sectional research sample targeting pivotal centers of settlement in Slovakia.

Primary data were procured through the Datacenter (Ministry of Finance of the Slovak Republic) and validated through pilot control using selected Final Accounts and Budgets of specific municipalities. Secondary control and adjustment procedures involve monitoring indicators from the INEKO organization and its database. The supplementation of missing primary data was executed through the study of economic and budgetary documents of the relevant self-governance entities. The total primary dataset comprised 6,000 entries, complemented by an additional 500 entries in the secondary data database. Such an extensive dataset is deemed adequate for verifying research questions and achieving the overarching research objective.

The first research question engages with the geographical distribution of the studied units across Slovakia. Consequently, regional affiliation serves as a foundational element for the research, with the distribution structured based on the regional division of Slovakia into eight regional self-governances.

Table 1. Regional affiliation of analyzed units of local self-governance (Data processed internally based on SO SR, 2024)

Regional self-government	Units of local territorial self-government
Bratislava self-governing region (BA)	Bratislava (city districts: Devínska Nová Ves, Dúbravka, Karlova Ves, Nové Mesto, Petržalka, Podunajské Biskupice, Rača, Ružinov, Staré Mesto, Vrakuňa), Malacky, Modra, Pezinok, Senec, Stupava
Trnava self-governing region (TT)	Dunajská Streda, Galanta, Hlohovec, Holíč, Piešťany, Senica, Sereď, Skalica, Šamorín, Trnava, Veľký Meder
Nitra self-governing region (NR)	Kolárovo, Komárno, Levice, Nitra, Nové Zámky, Šaľa, Štúrovo, Šurany, Topoľčany, Vráble, Zlaté Moravce
Trenčín self-governing region (TN)	Bánovce nad Bebravou, Dubnica nad Váhom, Handlová, Myjava, Nová Dubnica, Nové Mesto nad Váhom, Partizánske, Považská Bystrica, Prievidza, Púchov, Stará Turá, Trenčín
Žilina self-governing region (ZA)	Bytča, Čadca, Dolný Kubín, Kysucké Nové Mesto, Liptovský Mikuláš, Martin, Ružomberok, Tvrdošín, Žilina
Banská Bystrica self-governing region (BB)	Banská Bystrica, Banská Štiavnica, Brezno, Detva, Fiľakovo, Lučenec, Revúca, Rimavská Sobota, Veľký Krtíš, Zvolen, Žiar nad Hronom
Prešov self-governing region (PO)	Bardejov, Humenné, Kežmarok, Levoča, Poprad, Prešov, Sabinov, Snina, Stará Ľubovňa, Stropkov, Svidník, Veľké Kapušany, Vranov nad Topľou
Košice self-governing region (KE)	Košice (city districts: Dargovských hrdinov, Juh, Nad jazerom, Sever, Sídlisko KVP, Sídlisko Ťahanovce, Staré Mesto, Západ) Krompachy, Michalovce, Moldava nad Bodvou, Rožňava, Sečovce, Smižany, Spišská Nová Ves, Trebišov, Veľké Kapušany

Table 2. Size categories of analyzed units of local self-government (Data processed internally based on SO SR, 2024)

Number of inhabitants	Units of local territorial self-government
Up to 10,000 inhabitants	Banská Štiavnica, Fiľakovo, Krompachy, Modra, Sečovce, Smižany, Stará Turá, Štúrovo, Šurany, Tvrdošín, Veľké Kapušany, Veľký Meder, Vráble
10,000 to 15,000 inhabitants	Bytča, Detva, Holíč, Kolárovo, Kysucké Nové Mesto, Levoča, Moldava nad Bodvou, Myjava, Nová Dubnica, Revúca, Sabinov, Stropkov, Stupava, Svidník, Šamorín, Veľký Krtíš, Zlaté Moravce
15,000 to 20,000 inhabitants	Bánovce nad Bebravou, Dolný Kubín, Galanta, Handlová, Kežmarok, Malacky, Nové Mesto nad Váhom, Púchov, Rožňava, Senica, Sereď, Skalica, Snina, Stará Ľubovňa, Žiar nad Hronom
20,000 to 25,000 inhabitants	Brezno, Čadca, Dubnica nad Váhom, Dunajská Streda, Hlohovec, Partizánske, Pezinok, Rimavská Sobota, Senec, Šaľa, Vranov nad Topľou, Trebišov
25,000 to 53,000 inhabitants	Lučenec, Piešťany, Ružomberok, Topoľčany, Bardejov, Humenné, Levice, Liptovský Mikuláš, Komárno, Michalovce, Nové Zámky, Považská Bystrica, Spišská Nová Ves, Martin, Poprad, Prievidza, Zvolen
Regional cities	Banská Bystrica, Bratislava, Košice, Nitra, Prešov, Trenčín, Trnava, Žilina

The second research dimension is constructed based on the population size of the units under examination. Precise data on the number of inhabitants for individual towns, municipalities, and city districts are derived from the database of the Statistical Office of the Slovak Republic (SO SR), reflecting the most current values for the year 2021.

To compare and evaluate such a volume of data and autonomous variables, we created a simple overview table. Based on the average value during the years 2010-2022, the table determined the ranking of individual groups of units of local territorial self-government in

Slovakia. The better the average values a specific regional and size group/category exhibits, the better placement it achieves. The best ranking of variables will be at position 1. The second-best will be at position 2, and so on until the worst results, which will be values 8 (geographic aspect) and 6 (size category). In the event of a scenario where two specific groups/categories attain identical mean values, their ranking will be averaged (e.g., if they share the third and fourth lowest debt levels, their resultant ranking will be 3.5). For evaluating positive or negative outcomes, we use the classic premise (Table 3).

Table 3. Rating of variables and ranking determination

Variable	Positive aspect	Negative aspect
Total debt	Low	High
Debt service	Low	High
Current account balance	High	Low
Liabilities overdue in relation to current income	Low	High
Liabilities unpaid 60 days or more overdue in relation to current income	Low	High
Basic balance	High	Low
Investment intensity	High	Low
Net assets	High	Low
Immediate liquidity	High	Low
Quick liquidity	High	Low

This ranking, albeit relative, provides a streamlined capture of the results, acknowledging the diversity of the research sample and the multifaceted economic and financial indicators under consideration. In essence, the methodological approach applied herein aims to present a heretofore absent cross-sectional perspective on the public economy of local territorial self-governance in Slovakia, emphasizing potential regional disparities and the juxtaposition of results based on the population size of the most significant components of local territorial self-governance.

Given the constraints of the research and the limitations of this article, detailed findings cannot be exhaustively expounded. Thus, there exists substantial opportunity for identifying the most influential determinants shaping our findings. The limits of the research encompass specifically curated indicators, the designated research subject, the chosen sample, and the temporal framework. The authors acknowledge that alterations in the configuration of variables, indicators, and research temporalities could potentially yield divergent outcomes from those expounded by the authors. Consequently, it is imperative to comprehend and construe the research within the specified intents and declared methodological approaches.

3. Results

The outcomes of our investigation encompass the verification of two research questions focused on the analysis of the public economy within the context of local self-government in Slovakia spanning the years 2010 to 2022. Consequently, we will divide this section into two subsections.

3.1. Economic Outcomes of Local Self-Government in Terms of Regional Affiliation

Our research sample of 100 examined local self-governments was redistributed across eight regional self-governments. The average results of individual regional groups of self-governments in all 10 observed variables are comprehensively depicted in Figure 1.

Significant variations in total debt are evident among regions, with Trenčín self-governing region having the highest total debt (24.16%) and Bratislava self-governing region the lowest (11.56%). These differences may reflect diverse approaches to financing and indebtedness in respective areas. The basic balance value in the Nitra self-governing region is notably negative (-3.39%), indicating potential financial instability. Conversely, Košice self-governing region exhibits a positive value (2.95%), signaling a robust financial position.

Trenčín self-governing region and Košice self-governing region demonstrate the highest investment intensity (9.69% and 9.14%, respectively), indicating their strong commitment to development and infrastructure projects. The remaining regions fall within the moderate range (average 7.87%). The Bratislava self-governing region excels in immediate liquidity (311.20%), signifying a high ability to cover short-term obligations. The average liquidity across regions is 220.63%.

Values of net assets vary significantly among regions, with Trenčín self-governing region recording the highest values (426.81%) and Banská Bystrica self-governing region at the lower end of the scale with a value of 357.67%. These disparities reflect differing levels of assets and capital in distinct areas.

The values of immediate and quick liquidity exhibit variability among regions, with Trenčín self-governing region and Bratislava self-governing region excelling in these areas. Average values for regions are 220.63% (immediate) and 269.36% (quick).

3.2. Economic Outcomes of Local Self-Government in Terms of Population Size

Our research sample of 100 examined local self-governments was redistributed into six size categories based on population size. The average results of individual size categories in all 10 observed variables are thoroughly captured in Figure 2.

Significant differentials in aggregate indebtedness manifest across municipalities of varying magnitudes. Diminutive municipalities feature diminished total debt metrics, whereas regional urban centers showcase markedly elevated percentage values, intimating a plausible correlation between municipal scale and outlays associated with infrastructural endeavors.

Derived from empirical data, it is discernible that regional urban centers sustain a conspicuously escalated echelon of interest and debt service vis-à-vis their diminutive counterparts. This discernment may be construed as a corollary of a more intricate financial fabric and an augmented interest encumbrance within metropolitan vicinities.

The ascertained trajectory of mounting delinquencies and unpaid obligations within municipalities harboring larger populations implies that sizable urban agglomerations might grapple with more pronounced exigencies in the sphere of extant commitments, necessitating a granular investigation into the etiologies of these disparagements.

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Figure 1. Average results (2010-2022) of analyzed units of local self-government (Data processed internally based on (INEKO, 2024))

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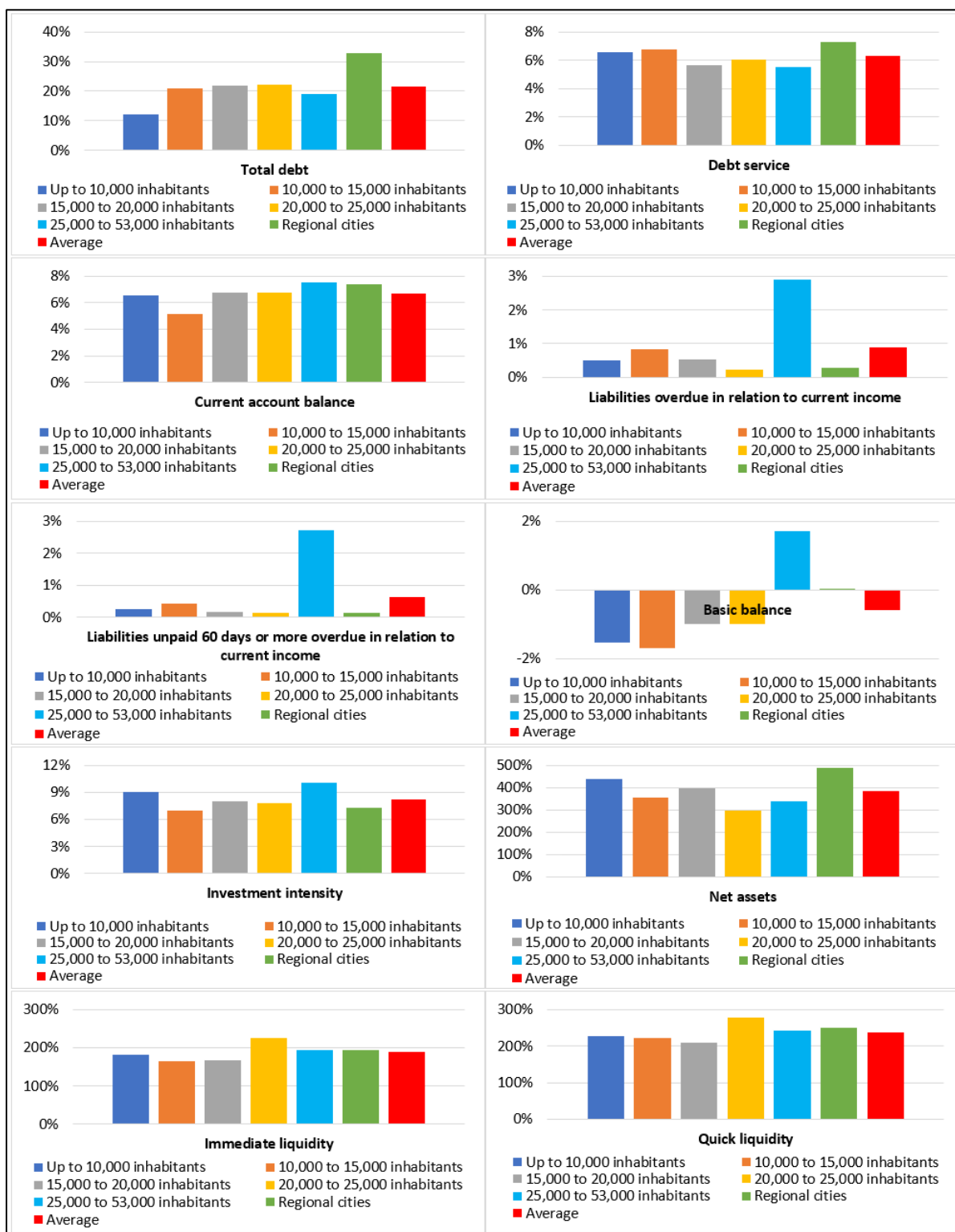
Figure 2. Average results (2010-2022) of analyzed units of local self-government (Data processed internally based on (INEKO, 2024))

grapple with more pronounced exigencies in the sphere of extant commitments, necessitating a granular investigation into the etiologies of these disparagements.

Balances within the fundamental accounts lean predominantly toward the negative spectrum in diminutive municipalities, signifying a predilection for outlays exceeding

inflows. In contrast, regional urban centers evince modestly affirmative or equilibrium values, intimating a conceivable amelioration in financial equilibrium.

The substantial augmentation in the intensity of investment within regional urban centers underscores their dedication to developmental initiatives and infrastructural ventures. Conversely, diminutive municipalities exhibit a more subdued intensity, potentially reflective of divergent prioritizations or constrained financial reservoirs.

Regional urban centers distinguish themselves favorably in terms of net assets and liquidity, alluding to their adeptness in fiscal resource administration and ostensibly signaling a robust financial posture.

4. Discussion

Through a comprehensive primary analysis involving data synthesis, classification, and summarization, we have generated graphical representations in Figures 1 and 2 aimed at validating our research inquiries. To address these inquiries conclusively, we undertook the task of establishing a partial ranking system for distinct groups within the framework of local territorial self-government units. The response to the initial research question, which intricately integrates the geographical dimension with the local public economy, will be extrapolated from the insights garnered through this process.

Table 4. Ranking of local territorial self-government units based on regional affiliation

	BA	TT	NR	TN	ZA	BB	PO	KE
Total debt	1	5	3	8	6	7	4	2
Debt service	1	3	7	8	2	5	6	4
Current account balance	6	5	8	1	2	4	7	3
Liabilities overdue in relation to current income	1	2	5	6	4	3	7	8
Liabilities unpaid 60 days or more overdue in relation to current income	1	2	4	5	6	3	7	8
Basic balance	6	3	8	5	4	2	7	1
Investment intensity	5	8	3,5	1	3,5	7	6	2
Net assets	5	4	8	1	7	2	6	3
Immediate liquidity	1	5	7	3	4	8	6	2
Quick liquidity	1	5	6	3	4	8	7	2
TOTAL	1	4	7	3	5	6	8	2

The primary analysis encompassing data synthesis, classification, and summarization culminated in the construction of graphical depictions presented in Figures 1 and 2, aimed at substantiating the veracity of our research inquiries. To substantiate and articulate conclusive responses, we undertook the task of ascertaining the partial ranking of distinct cohorts within the domain of local territorial self-governing entities. The elucidation of the initial research question, encapsulating the geographic facet conjoined with the local public economy, will be predicated upon the discernments derived from our investigations.

The preliminary scrutiny of the ultimate hierarchy discloses conspicuous disparateness among geographically dispersed units of local territorial self-governance. The units emanating from the Bratislava self-governing regionemerge as unequivocal pacesetters, exhibiting preeminent outcomes across a spectrum of six dimensions (Total debt, Debt service, Liabilities overdue in relation to current income, Liabilities unpaid 60 days or more

overdue in relation to current income, Immediate liquidity, Quick liquidity). A comprehensive generalization of these outcomes prompts the assertion that urban conglomerations, urban enclaves, and the municipal administration of the metropolis have demonstrated superlative economic and financial performance within an extended temporal purview, as scrutinized through a comprehensive set of ten variables.

Closely tailing this echelon are the autonomous entities of local governance situated in eastern Slovakia, more specifically, within the Košice self-governing region. It is noteworthy that urban conglomerates, urban precincts, the municipal administration of Košice, and the municipality of Smižany have recorded the most suboptimal outcomes (Liabilities overdue in relation to current income, Liabilities unpaid 60 days or more overdue in relation to current income) despite securing a secondary standing.

The scrutinized units of local territorial self-governance within three disparate regions have exhibited a remarkably consonant pattern, distinctly manifesting in the ultimate hierarchical order. The third, fourth, and fifth positions in the hierarchy of superior economic indicators are occupied by the self-governing entities from Trenčín self-governing region, Trnava self-governing region, and Žilina self-governing region. While the specific metrics may oscillate, the inter-cohort differentials in the conclusive standings remain inconsequentially marginal.

Evidently, the nadir of economic performance within local vicinities is inhabited by urban settlements in the southwest (Nitra self-governing region) and northeast (Prešov self-governing region) of Slovakia, persistently relegating them to the terminus of the hierarchy. Of particular intrigue is the revelation concerning the public economic outcomes of urban centers in the Prešov self-governing region, wherein their optimal standing was confined to the fourth position (Total debt). Conversely, these entities routinely reported values that invariably consigned them to terminal placements.

In the authentication of the primary research question, regional differentials in the governance of selected entities within the purview of local territorial self-governance in Slovakia have been irrefutably corroborated. The scrutiny and correlation of foundational data elucidated that entities situated within the Bratislava and Košice self-governing regions manifested significantly superior outcomes across ten selected indicators of economic disposition. The urban precincts within these regions emerged as paragons, registering some of the most commendable values among the entire gamut of scrutinized economic indicators. By contrast, urban centers within the Nitra and Prešov self-governing regions consistently found themselves positioned at the nadir, manifestly indicating a profound incongruity in the outcomes of their economic endeavors and financial situations.

The second research task was designed to identify optimal economic units of territorial self-government based on ten observed indicators in relation to the size of the population. The resulting final ranking of size groups clearly identifies which cities with a high population achieved the best results during the years 2021-2022.

Table 5. Ranking of analyzed units of local self-government by population size (number of inhabitants):

	Up to 10,000	10,000-15,000	15,000-20,000	20,000-25,000	25,000-53,000	Regional cities
Total debt	1	3	4	5	2	6
Debt service	4	5	2	3	1	6
Current account balance	5	5	4	3	1	2
Liabilities overdue in relation to current income	3	5	4	1	6	2
Liabilities unpaid 60 days or more overdue in relation to current income	4	5	3	2	6	1
Basic balance	5	6	3,5	3,5	1	2
Investment intensity	2	6	3	4	1	5
Net assets	2	5	3	6	4	1
Immediate liquidity	4	6	5	1	3	2
Quick liquidity	4	5	6	1	3	2
TOTAL	4	6	5	3	1	2

The results of the ranking bring significant findings. In general, based on the conducted analysis, it can be stated that significantly worse results in the observed ten indicators were achieved by smaller territorial units. The specific threshold or boundary is the number of inhabitants up to 20,000, and the analyzed territorial units in this group show more negative data than larger units. Selected cities belonging to the category of more than 20,000 inhabitants and regional cities achieved, on average, distinctly better levels of economic indicators of financial health. The difference in the ranking of the first three size categories is minimal. For the size category of cities that exhibit the best average results in the ten observed indicators, based on our research, we can designate the category of 25,000 to 53,000 inhabitants, closely followed by regional cities and the size category of 20,000 to 25,000 inhabitants. At the end of the ranking and the metaphorical ladder, cities belonging to the category of 10,000 to 15,000 inhabitants settled.

To verify and qualify the answer to the second research question, it can be stated that comprehensively, the highest average level of public economy is achieved in Slovakia by territorial units with a population higher than 20,000 inhabitants. Our research indicates that the most optimal and best values of the observed indicators were recorded in cities with a population from 25,000 to 53,000 inhabitants. This result suggests that larger Slovak urban agglomerations and entities are more effective in managing their public economy.

Regional affiliation likely plays a significant role. Cities in the Bratislava and Košice self-governing region appear to achieve better results in many monitored indicators. The reasons may vary – from better economic infrastructure and increased investment influx to more effective financial management.

Another factor is population size. In general, cities with a higher number of inhabitants tend to achieve better results. Cities with a population exceeding 20,000 exhibit better indicators of economic stability compared to smaller towns. Of course, even in other smaller towns, above-average and positive values of the investigated ten variables can be found. However, when generalizing the results for entire size groups, it is more of an exception.

Given the apparent regional disparities in the economic performance of individual territorial self-governments, it is imperative for policymakers to consider the implementation

of targeted policies and interventions to address specific issues in areas with lower economic indicators. A holistic understanding of the unique economic dynamics of each region is crucial for effectively designing policies.

Regions with lower economic indicators could benefit from initiatives that promote economic development, such as improving economic infrastructure, attracting investments, and creating a business-friendly environment. Identifying and addressing factors contributing to inequalities can contribute to the formulation of targeted strategies.

Cities and local self-governments, especially those with lower economic indicators, could benefit from training programs focused on efficient financial management. Enhancing financial literacy and adopting best practices in financial management can contribute to improving economic stability.

Considering the correlation between population size and economic performance, resource allocation strategies could be adjusted to prioritize regions with larger populations. This may involve directing investments, infrastructure projects, and economic development programs toward areas with higher population density.

Smaller cities (up to 20,000 inhabitants) could benefit from targeted support programs tailored to their specific challenges. This could include initiatives to strengthen capacities, grants, or joint projects aimed at improving their economic stability.

5. Conclusions

The main goal of our study was to scrutinize public economy within the framework of local territorial self-government in Slovakia since 2010. The research focused on monitoring ten indicators of public economy within the context of local territorial self-government during the specified time period. Individual partial data were categorized based on geographical affiliation and size category. The study's findings highlight significant geographical disparities, with the most favorable average results observed in territorial self-governments within the Bratislava and Košice self-governing regions. These conclusions are further corroborated by the size of specific units of local territorial self-government, demonstrating that optimal results are achieved by larger cities and regional cities with a population exceeding 20,000 inhabitants. The conclusions of our research, grounded in extensive primary data, are constrained by the time series, the selection of the research sample, and the variables themselves. We do not preclude the possibility that our conclusions could be nuanced if alternative indicators were incorporated or if the research sample were exchanged in the study's implementation. Undoubtedly, this issue presents significant potential for further in-depth analyses that can serve as a compelling argument in discussions regarding the role and position of cities in Slovakia.

During the presentation of research results, we are compelled to take into account the limitations of the scope of our work. Our endeavor aimed at providing the most detailed and relevant perspective on our findings within the available scope. It is important to bear in mind that research results can be extensive and complex, and thus, we sought to present a concise yet informative overview in accordance with the defined parameters of the scope.

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The Analysis of Legal Regulations for Establishing and Operating Reuse Centers or Points

Eva Daniela CVIK*, Jana HINKE and Gabriela KUKALOVÁ

University of Life Sciences Prague, Prague, Czech Republic; cvik@pef.czu.cz; hinke@pef.czu.cz; kukalova@pef.czu.cz

* Corresponding author: cvik@pef.czu.cz

Abstract: The circular economy and sustainability are concepts that are mutually interconnected and have been the subject of debate and research. The circular economy primarily focuses on the sustainable use of resources. Reuse centers and reuse points are concrete examples of implementing the reuse principle, which contributes to a more efficient use of resources and a reduction of the negative impact on the environment. Establishing and running a reuse center or reuse point has several positive impacts (economic, environmental, and social), but there are also legal aspects that need to be considered when deciding on the form and system of their operation. The aim of this paper is to identify the legal norms (laws and decrees) as well as other legal regulations that are applicable to the topic of establishing re-use centerst/re-use points. This includes a comparative analysis of the current forms of establishing these operations to summarize the advantages, disadvantages, and risks accosiated with each form. Another objective is to synthesize these legal regulations into basic clusters according to their relevance to different aspects of the operation of re-use centers/reuse – points.

1. Introduction

Reuse centers and reuse points are facilities or places that focus on promoting the reuse and recycling of items. These centers help reduce waste and promote sustainability by extending the lifetime of things and minimizing the consumption of new raw materials. Sustainability encompasses economic, social, and environmental dimensions, seeking to balance the needs of people and the preservation of resources. As stated by Nilashi et al. (2019), nowadays sustainability is recognized as one of the most important paradigms of development and is included in the international and national strategies of almost all organizations. The schemes used by organizations to manage sustainability efforts are evaluated by Demastus and Landrum (2023) in their research. According to Hicks and Nergard (2023), the sustainability of a particular place is also influenced by the physical and social infrastructure of the environment. Sustainability is linked to the circular economy as they share common goals of efficient use of resources, minimizing waste, and avoiding or reducing negative environmental impacts. The circular economy is considered an alternative

to the existing economic activity models and has become one of the newest ways to address environmental sustainability (Pichlak, 2018; Bareiro-Gen & Lozano, 2023). The principles of adoption or barriers to the implementation and development of the circular economy are therefore the subject of research, which is addressed, for example, by Garfström and Aasma (2021), Patwa et al. (2021), or Sorensen et al. (2020).

Reuse centers, or reuse points, play an important role in the circular economy. The concept of reuse is defined by the EU Directive 2018/851/EU (2018) as an activity in which products or components that do not constitute waste are reused for the same purpose for which they were created. As Milios (2018) states, reuse brings environmental, social, and economic benefits. The potential and environmental benefits of reusing end-of-life products are reported, for example, by Milios and Dalhammar (2020) or Maier et al. (2020). Social and societal benefits are mentioned by Gorissen et al. (2014). Economic aspects of reuse centers and reuse points are examined by, e.g., Zacho et al. (2018) or Zajko and Hojnik (2014).

In the Czech Republic, establishing a reuse center or reuse point should be done with respect to local legislation, the market, and the needs of the community. A reuse center is usually a larger facility through which other services can be offered, including recycling and waste education activities. A reuse point is a designated place where items that can still be used are deposited. Sustainability in the context of reuse centers and reuse points is a key element that should reflect their entire operation. Establishers should familiarize themselves in detail with the relevant legislation and regulatory requirements relating to the operation and responsibility for a reuse center or reuse point. Non-legal aspects, such as communication and cooperation with local authorities and stakeholders or securing funding for its operation, also play an important role in the establishment of a reuse center or reuse point.

A legal entity, a natural person doing business, or a state or local government body can become the founders of reuse centers or reuse points. For the purposes of this article, the establisher is categorized into private entities, i.e., natural persons (self-employed persons), legal persons that are established directly by natural persons, and state or local government bodies. Given the scope of the legal environment of the area, this paper focuses on the analysis of the legal regulations related to the moment of selecting the legal form for establishing a reuse center or reuse point and subsequently on defining the legal regulations related to their operation. The authors see the importance of this topic since the legal regulations relating to this topic are fragmented within the legal system, and therefore the relevant provisions of law have to be extracted and grouped together according to the problem area addressed.

The aim of this paper is to identify the legal norms (laws and decrees) as well as other legal regulations that are applicable to the topic of establishing re-use centerst/re-use points. This includes a comparative analysis of the current forms of establishing these operations to summarize the advantages, disadvantages, and risks accosiated with each form. Another objective is to synthesize these legal regulations into basic clusters according to their relevance to different aspects of the operation of re-use centers/reuse – points.

2. Methodology

Several complementary scientific methods will be used to meet the set objectives. To elaborate on an analysis of the legal regulations for establishing and operating a reuse center or reuse point, we will use both literal and extensional methods of interpretation of the law. In particular, the latter will be applied to the relevant legal regulations at the level of acts and decrees. Furthermore, the scientific method of desk research, the method of analyzing legal regulations and decrees, and the method of data comparison will be used. Another method that will be employed is the method of clustering legal regulations into individual groups, according to which a methodology for establishing and operating a reuse center or reuse point will be drawn up.

To achieve the set objective, the following research questions have been formulated:

1. What legal norms govern the establishment of re-use centers/re-use points, and what forms are currently available under these legal norms? What are the advantages, disadvantages, and risks associated with each legal form?
2. Is it crucial for establishing a reuse center or reuse point which entity (private or public) establishes the reuse center or reuse point?
3. What legal norms identify the issues of operating a reuse center or reuse point, or more precisely, what basic clusters can be defined for these legal norms?

All legal regulations referred to herein are stated as subsequently amended.

3. Results

3.1. The Analysis of the Legal Forms of Establishing a Reuse Center, a Reuse Point, and the Identification of Legal Regulations

Reuse centers or reuse points can be operated by natural persons (in the Czech Republic referred to as self-employed persons), by trade corporations acting in legal relations as private entities, or by local governments through legal persons or trade corporations that are defined and regulated for this activity in the Czech legal system. The legal system of the Czech Republic defines several legal persons and trade corporations that are used in practice for establishing reuse centers and reuse points. Selecting the legal form for a reuse center or reuse point depends on several factors, including the objective of the organization, its structure, funding, and legal obligations. The entity establishing the reuse center or reuse point also represents an important factor in the establishment process. The process of establishment itself, i.e., the choice of the most appropriate legal form, subsequently influences the operation in terms of the need to comply with the obligations that are regulated by the relevant legal norms relating to the operation.

First of all, the establisher should define factors that will enable them to select the most appropriate legal form for operating the reuse center or reuse point:

1. Defining the objectives: The objectives of a reuse center or reuse point should be defined by the establisher before the establishment process. Whether the founder's priority and

primary objective are to achieve social or environmental gains, or whether the established reuse center or reuse point should have a commercial aspect, should be defined.

2. Profitability of the reuse center or reuse point: This is an entirely fundamental question when selecting the legal form of the reuse center or reuse point. At the very beginning of the establishment, it should be decided whether the reuse center or reuse point is to be a profit-making organization or a non-profit organization. This decision subsequently affects the way the operation is financed and the tax obligations.

3. Financial aspects: financial aspects, including available funding sources, must be considered for running a reuse center or reuse point. Non-profit organizations can secure their funding through subsidy programs or grants, while commercial entities most often rely on their revenues or on financial support from other private entities. Reuse centers and reuse points can also be funded through public fundraising. A public fundraising campaign is not directly a legal person. Only legal persons, not individual citizens, are entitled to organize public fundraising (Act No. 117/2001 Sb.).

4. Stakeholders' interests: the selected legal form of the reuse center or reuse point should respect the following interests: These are the interests of the local communities (creating job opportunities, the possibility of being involved in the recycling and reuse process, benefits for the local economy), the interests of employees (retraining opportunities, support of unemployment, support of weak social groups), the interests of business partners (maintaining stable business relations, transparent communication, establishing cooperation), and the interests of investors or financing organizations (securing return on investment, long-term sustainability of projects, transparent financial management).

5. Legal liability and risks: To select the right legal form of reuse center or reuse point, personal liability, tax burden, and risks associated with the legal form in question must be taken into account.

6. Sustainable business plan: the selected legal form should allow for future development and adaptation to changes, both market and legal. Therefore, strategies and long-term plans for the operation of them must be defined prior to establishing the reuse center or reuse point.

Depending on their objectives, structure, and needs, reuse centers and reuse points can take different legal forms in the Czech Republic. However, the legal status of the establisher means a certain limitation, which must also be considered in this context. There is no legal limitation in terms of the private entity as the establisher. In the case of the establisher being a state authority or a local government authority, the limitation is directly defined by the legal regulations.

The establishment of a facility by a private entity

A private entity can establish and operate a reuse center or reuse point as a business entity that is intended to make a profit, not only through the legal forms of trade corporations but also through conducting business activities using a trade license. When selecting the legal form (Table 1) for establishing a reuse center or reuse point, it is

important to understand that there is a certain risk of limited access to external financing. An equally important aspect is that within these legal forms, a social or environmental focus may be lacking. Considering that legal forms such as corporations or sole proprietorships are established to generate profit, the financing of the operation of the reuse center or reuse point is also secured to some extent.

Table 1. The comparison of legal forms for establishing a reuse business when the business entity is a profit-making private entity (Part 1)

Form	Limited liability company	Joint-stock company	Cooperative	Licensed trade	General commercial partnership
Characteristics	Limited liability company. The founders hold shares in the profits and have limited liability. The executive director bears personal liability for the company's debts in the given circumstance, involving the encumbrance of their personal assets. Legal provisions govern the particulars of such instances	A joint stock company is a form of business entity that issues its own shares. It is suitable for larger projects and makes it possible to raise capital from shareholders. Shareholders have an ownership interest in the business corporation.	It is only an option when the cooperation and participation of individual members are emphasized. To operate a reuse center or reuse point, this legal form of operating a social cooperative should be chosen.	Operated on one´s own responsibility. Suitable for smaller reuse centers and reuse points. Obtaining a trade license is required, the categorization of which will be based on the type of activity carried out. Carried out by a natural person as a self-employed person.	Characterized by a democratic management style. Individual members decide on business matters.
Legal regulations	Section 132 et seq. of Act No. 90/2012 Sb., on Business Corporations and Cooperatives	Section 243 et seq. of Act No. 90/2012 Sb., on Business Corporations and Cooperatives	Section 552 et seq. of Act No. 90/2012 Sb., on Business Corporations and Cooperatives	Section 45 et seq. of Act No. 455/1991 Sb., the Trade Licensing Act	Section 95 et seq. of Act No. 90/2012 Coll., on Business Corporations and Cooperatives
Advantages	Low share capital of 1 CZK.	High capital stock.	Cooperative members actively participate in the decision-making process. Each member has the right to participate in strategic operational issues.	Simple, quick, and time- and money-saving establishment of a licensed trade.	It does not create share capital.

Table 1. The comparison of legal forms for establishing a reuse business when the business entity is a profit-making private entity (Part 2)

Form	Limited liability company	Joint-stock company	Cooperative	Licensed trade	General commercial partnership
Disadvantages	The executive director bears personal liability for the company's debts in the given circumstance, involving the encumbrance of their personal assets. Legal provisions govern the particulars of such instances. There exists a restricted option for discontinuing share participation in the company.	Shareholders' equity participation is intended only for large projects; in the authors' opinion, this is not a suitable form for reuse centers or reuse points.	Less flexible than a limited liability company or joint stock company, which reduces the speed of response to market changes and new opportunities.	Unlimited liability for the debts of the reuse center or reuse point, i.e., by the natural person's entire property.	Unlimited liability, dependence on members who bring their own personal know-how to the company.
Risks	Lack of social orientation, lack of social or environmental orientation.	Open ownership leads to reduced control by founders and companies.	All members of the cooperative share responsibility for losses.	Professional qualifications or education are required for some activities performed at the reuse center or reuse point.	Persons are jointly and severally liable for debts with all their property.

Act No. 90/2012 Sb., the Business Corporations Act, regulates another type of business corporation under Section 118. This is a limited partnership, which can be defined as a company combining elements of a limited liability company and a general commercial partnership. According to the authors, this partnership can be used for operating a reuse center or reuse point, but its internal structure appears to be complicated for operation.

A private entity can establish and operate a reuse center or reuse point with an emphasis on social and environmental aspects. To fulfill these aspects, the legal form of non-profit organizations is chosen (Table 2). Using this legal form, reuse centers and reuse points most often provide employment opportunities for people who may have limited access to the labor

market, offer education and training programs, or carry out educational activities by informing the public about the importance of sustainability and reducing negative environmental impacts. Thus, the legal form of non-profit organizations is not focused on generating profit for the reuse center or reuse point.

Table 2. The comparison of legal forms for establishing a reuse business in the legal form of non-profit organization – a private entity

Form	Association	Endowment Fund/Foundation	Institute
Characteristics	The association is composed of individuals sharing common interests and objectives. Members come together to pursue their set objectives.	Suitable for a reuse center or reuse point, especially if the organization is primarily engaged in social, scientific, educational, and environmental activities.	Suitable for the operation of a reuse center or reuse point in the case of welfare activities, including projects focused on sustainability and reuse. Carrying out socially or economically beneficial activities.
Legal regulations	Section 214 et seq. of Act No. 89/2012 Sb., the Civil Code	Section 306 et seq. or Section 394 et seq. of Act No. 89/2012 Sb., the Civil Code	Section 402 et seq. of Act No. 89/2012 Sb., the Civil Code
Advantages	A flexible legal form that is used for organizations with a community or social focus.	Independent of short-term fluctuations in finance, it may have its own sources of funding through its assets or investments.	A flexible legal form that is used for organizations with a community or social focus.
Disadvantages	Dependence on funding from membership fees, donations, grants, or other forms. Inability to trade.	It owns and administers its own assets or raises funds, but these must be used only to support specific objectives and projects.	An initial capital deposit or funds to underwrite the activities of the institute must be paid.
Risks	Association members are liable for the association's debts by their property.	Uncertainty and risk if it depends on only one source of funding.	The organization's projects may depend on social and environmental changes.

It is also possible to encounter a charitable trust in practice. This legal person is not listed in the table above because the possibility of establishing a charitable trust was removed with the adoption of Act No. 89/2012 Sb., the Civil Code. Charitable trusts that were established before Act No. 89/2012 Sb., the Civil Code, came into force, i.e., prior to January 1, 2014, could remain in this legal form (Section 3050 of Act No. 89/202 Sb., the Civil Code) or choose to transform into another legal form (foundation, endowment fund, or institute). In the present legal regulations, a charitable trust takes the form of an institute.

If the founder of a reuse center or reuse point needs to set up a business model that integrates social or environmental objectives, the Czech legal system enables them to establish a social enterprise. This form emphasizes achieving social or environmental objectives together with economic sustainability, where the value of a social enterprise is measured not only by financial results but also by social impact. A social enterprise differs from a regular business corporation in its core objectives, attitudes, and the way it creates

values for society. Not every business that identifies itself as a social enterprise is a social enterprise. Social enterprises include businesses that employ disadvantaged people, are environmentally focused, support local development, or engage in fair trade activities. Social enterprise thus combines the economic, social, and environmental dimensions of doing business. Given the nature of the social enterprise's objectives, it can therefore be concluded that it is a hybrid legal form containing elements of a business corporation and non-profit organizations. In the Czech Republic, a social enterprise may select several legal forms for its establishment, which allow for linking business with achieving social or environmental objectives. A social enterprise can take the form of a limited liability company, joint-stock company, cooperative, social cooperative, association, foundation, or self-employed person.

Table 3. Comparing the characteristics of a social enterprise and a social cooperative

Form	Social enterprise	Social cooperative
Characteristics	These are business entities in various legal forms that aim to combine business with achieving social or environmental objectives. The legal forms of a social enterprise can be limited liability company, joint stock company, cooperative, social cooperative, institute, association, foundation, and sole proprietorship. To be defined as a social enterprise, an organization must fulfill public-beneficial objectives that are already defined in the founding documents. Upon its establishment, a social enterprise defines its business activities with an emphasis on social and environmental objectives.	It can be established since 2014. It is based on the principles of social entrepreneurship. It is a cooperative, and in defining its objectives, it can opt for the form of a social enterprise. It consistently carries out activities of public benefit to promote social cohesion. The organization comprises the term "social cooperative."
Legal regulations	The legal regulation of the forms of commercial corporations is Act No. 90/2012 Sb., on Business Corporations and Cooperatives. The legal regulation of non-profit organizations is Act No. 89/2012 Sb., the Civil Code. The legal form of a licensed trade is Act No. 455/1991 Sb., the Trade Licensing Act.	Section 758 of Act No. 90/2012 Sb., on Business Corporations and Cooperatives
Advantages	It is established based on the founders' decision and can be registered under different legal forms— there is a high degree of flexibility. Some entities find it important that a business corporation be mindful of social and environmental responsibility. Better reputation, better attraction of customers and business partners.	A good reputation is an effective tool for business with benefits for society. It is in line with the stated objectives, i.e., creating jobs and supporting the community.
Disadvantages	Fundraising is more difficult. Prioritizing social and environmental objectives can limit profitability. Goals are firmly stated in the founding documents. They cannot be changed or modified.	The objectives are clearly defined in the founding documents. They cannot be changed or modified.
Risks	Business partners may have limited awareness of the concept of social entrepreneurship.	Joint liability of members for the operation and debts of the cooperative.

The term social enterprise is not directly defined by law in the Czech Republic within a single legal norm. The concept of a social enterprise is embedded and intertwined in a number of legal regulations governing the conditions of business activities and social care, or in the Employment Act (Table 3).

The Ministry of Labor and Social Affairs has submitted a bill on social enterprise and amendments to related acts to the Chamber of Deputies. This bill introduces the concept of social economy into the legal system of the Czech Republic and sets out its sub-characteristics. The proposed legal regulation enshrines the means to support registered social enterprises, which should be used to provide comprehensive assistance with the sustainable development of social business activity ("Bill on Social Enterprise").

Establishing a business by a state or local government authority, focusing on municipalities

Under the Czech legal system, only municipalities with an extended scope of authority have the right to establish business corporations (Section 35a of Act No. 128/2000 Sb., Section 14(3) of Act No. 129/2000 Sb.). However, municipalities and regions are limited in establishing business corporations by the fact that the object of the business activities of the established business corporation must be related to the performance of municipal tasks assigned to municipalities in accordance with the relevant legislation. Municipalities may be founders of both legal persons under public law (state-funded organizations) and founders of legal persons and business corporations under private law.

The municipality is entitled to set up a state-funded organization within the meaning of the relevant act (Act No. 218/2000 Sb.). Municipalities and regions can establish state-funded organizations for such activities, which are usually not-for-profit and whose scope and complexity require a separate legal personality. A state-funded organization is therefore a legal person that is established as a state, non-profit organization with a defined public interest. Providing useful services or activities is usually the main objective of a state-funded organization.

Reuse centers and reuse points can also be operated as waste recycling centers (Table 4), especially if the waste recycling center allows for waste separation, repair, or reuse of materials and items. The Czech Republic does not have a specific legal form for waste recycling centers, and their operation can be organized in several ways. Most waste recycling centers are part of the waste management system, and the waste recycling center is operated by the municipality or town, often in cooperation with waste management companies.

3.2. The Identification of Legal Norms Governing the Operation of Reuse Centers, Reuse Points, and their Categorization into Clusters

The operation of reuse centers and reuse points in the Czech Republic is subject to several key legal aspects. For the purposes of this article, the authors list the most important legal regulations (Table 5 and Table 6) that must be complied with in the operation of reuse centers

Table 4. The comparison of the legal forms for the establishment of a reuse facility - a municipality, a city, or a region as a founder

Form	Business corporation	State-funded organization	Waste recycling center	Foundation/endowment fund, association, civic association
Characteristics	Legal limitations for establishing a business corporation must be met; the object of the business corporation must be in accordance with the tasks of the municipality. A municipality may be an owner and may have an ownership interest in a business corporation.	The aim is to provide useful services or activities. It can be established by the municipality, which then finances it. The aim is not to make a profit.	There is no specific legal form in the Czech Republic. Waste recycling centers are part of the waste management system or are operated by municipalities in cooperation with waste management companies, which are established as business corporations.	The conditions set out in Table 2 apply.
Legal regulations	Act No. 90/2012 Sb., on Business Corporations	Act No. 218/2000 Sb., on Budgetary Rules	Act No. 90/2012 Sb., on Business Corporations	Act No. 89/2012 Sb., the Civil Code
Possible legal forms	limited liability company, cooperative, general commercial partnership	State-funded organization	limited liability company, joint stock company	Foundation, endowment fund, association, civic association

and reuse points under the Czech legal system. However, in this context, it needs to be stressed that regarding the business plan and set objectives that precede the establishment of reuse centers and reuse points, they predetermine, to a certain extent, compliance with the relevant legal regulations. In this sense, the legal regulations can be classified as follows:

- the legal regulations that reuse centers and reuse points are required to comply with in their internal operations (tax compliance, bookkeeping, etc.); and
- in its external operations (business relations with third parties, sales, liability for defects, etc.).

4. Discussion and Conclusion

The research questions have been answered based on the defined methods, i.e., the method of interpretation of the relevant legislation at the level of statutes and decrees, the method of analysis of legal regulations and decrees, and the method of comparison of the obtained data. In connection with answering the first research question, two groups of legal persons have been characterized, with emphasis on the entity that establishes the legal person. In the case of operating reuse centers and reuse points as non-profit organizations, one has to take into account the lack of financial resources for the operation of reuse centers and reuse points and a certain degree of financial dependence on third parties. In the case of

Table 5. Synthesizing the legal regulations related to the internal operation of reuse centers and points

Field of law	Issues addressed	Legal norm
Commercial law	- Establishment, entry in the public register	Act No. 89/2012 Sb., the Civil Code Act No. 90/2012 Sb., on Business Corporations and Cooperatives Act No. 304/2013 Sb., on Public Registers
	- Performing administrative duties with respect to the public register (financial statements, audit, etc.) - Keeping a record of the real owners	Act No. 90/2012 Sb., on Business Corporations and Cooperatives Act No. 304/2013 Sb., on Public Registers
Financial law	- Accounting records, records of accounting transactions	Act No. 563/1991 Sb., on Accounting
	- Tax obligations	Act No. 586/1992 Sb., on Income Tax Act No. 235/2004 Sb., on Value Added Tax Act No. 338/1992 Sb., on Real Estate Tax
Civil law	- Lease agreement, contracts relating to internal affairs	Act No. 89/2012 Sb., the Civil Code
Labor law	- Industrial relations, - Relations with self-employed persons	Act No. 262/2006 Sb., the Labor Code Act No. 89/2012 Sb., the Civil Code
Administrative law	- Occupational safety, fire protection, and hygiene	Act No. 309/2006 Sb., Further Requirements on Occupational Health, and Safety Act No. 133/1985 Sb., on Fire Protection Act No. 258/2000 Sb., on Protection of Public Health
	- Waste law, waste sorting and waste management rules. In some cases, it is necessary to obtain a permit for waste collection and sorting. - Registration fees for waste production and management	Act No. 185/2001 Sb., on Waste Act No. 565/1990 Sb., on the Local Fee.
	- Protection of the environment	Act No. 76/2002 Sb., on Integrated Prevention and Reducing Pollution

Table 6. Synthesizing the legal regulations related to the external operation of reuse centers and points

Field of law	Issues addressed	Legal norm
Civil law	- contractual relations with business partners /it also applies to PO/ - contractual relations with third parties - gifts (donations), contributions - warranties for goods - operation of the online shop / it also applies to PO/	Act No. 89/2012 Sb., the Civil Code
	- Consumer protection - Personal data protection	Act No. 89/2012 Sb., the Civil Code Act No. 634/1992 Sb., on Consumer Protection Regulation 2017/2394/EU, on consumer protection Act no. 101/2000 Sb., on Personal Data Protection Regulation 2016/679/EU. General Data Protection Regulation

operating reuse centers and reuse points through a business corporation, the absence of social, environmental, and sustainability elements, which are the main characteristics of reuse centers and reuse points, must be avoided.

The analysis has shown that the present legislation does not sufficiently deal with the existence of legal entities that would incorporate both the element of non-profit activity and the element of business activity in aggregate. Such a form of legal entity would be beneficial for reuse centers and reuse points as it would ensure their potential financial dependence on third parties to a certain extent, whereby reuse centers and reuse points could carry out business activities, and at the same time, the main characteristics of reuse centers and reuse points would be satisfied. While the current legal order provides for the possibility of operating a social cooperative, this legal concept has not yet been sufficiently regulated. The authors appreciate the current initiative of the Ministry of Labor and Social Affairs to submit the Act on Social Enterprise and on Amendments to Related Acts, as the adoption of this Act would contribute to the development of business activities with an implemented social aspect.

Having analyzed the second research question, it has been found that the entity establishing a reuse center or reuse point is crucial for the establishment of the reuse center or reuse point. In the case of a private entity, it is not constrained by the legal order when choosing a legal norm. The opposite situation occurs when the founder is a state authority or a self-governing territorial unit, which is bound by the legal order of the Czech Republic and is thus limited in its choice of the legal form of the reuse center or reuse point.

In the case of identifying the legal sources regulating the operation of reuse centers and points, the basic legal norms and other regulations were defined and clustered into two basic groups: those related to internal operation and those related to external operation. These two basic clusters were further classified by the law types.

The authors positively assess the current initiative of the Ministry of Labour and Social Affairs, which is the proposer of the law on social enteprise and the amendment of related laws. The adoption of this law would contribute to the development of business with an integrated social aspect so that enterprises with a social focus become a natuar part of the Czech economy as well (as stated by Tauš Procházková et al., 2021). As Lambooy et al. (2021) point out, many EU member states provide legal forms tailored to social enterprises.

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Game Theory and Agent-Based Models in Epidemiology: Exploration of Strategies with NetLogo

Jiří ČERNOHORSKÝ, Stanislav ŠAFRÁNEK* and Kamila ŠTEKEROVÁ

University of Hradec Kralove, Hradec Kralove, Czech Republic; jiri.cernohorsky@uhk.cz; stanislav.safranek@uhk.cz; kamila.stekerova@uhk.cz

* Corresponding author: stanislav.safranek@uhk.cz

Abstract: The paper deals with the fusion of game theory and computational epidemiology. It presents an agent-based simulation that demonstrates how game theory principles can be used to study the effects of individual decision making in an epidemic situation. Our model of a symmetric repeated vaccination game with imperfect information was developed using NetLogo. Players decide whether or not to vaccinate by weighing the costs of vaccination against the potential costs of disease. The decisions of neighbors and the course of epidemic determine the costs. Different diseases and scenarios can be simulated by manipulating the model with input parameters. The model allows the number of infections, the number of players following a particular strategy, and the highest payouts for players in each of the three states. Four experiments were conducted.

Keywords: agent-based model; epidemiology; game theory; model; NetLogo; simulation

JEL Classification: C53; D71

1. Introduction

Despite considerable technological and medical progress in our society, we have failed to react promptly and adjust to the COVID-19 pandemic outbreak. It has become apparent that a comprehensive strategy and the resources to manage the intricacies of pandemic scenarios, the various factors influencing their progression, and human behavior are missing in our society. Our study adds to existing models of individual decision-making concerning vaccination and other anti-pandemic interventions through the application of game-theoretic principles in agent-based models.

1.1. Mathematical Modelling of Epidemics

Batista et al. (2021) argue that epidemiological models classify individuals in a population into the following categories: Susceptible (S), Exposed (E), Infected (I), Recovered (R). The model dynamics are determined by the rate of movement of an individual between categories. The most frequent transitions among these categories are:

- SIS (Susceptible – Infected – Susceptible),
- SIR (Susceptible – Infected – Recovered),
- SIRS (Susceptible – Infected – Recovered – Susceptible),
- SEIR (Susceptible – Exposed – Infected – Recovered).
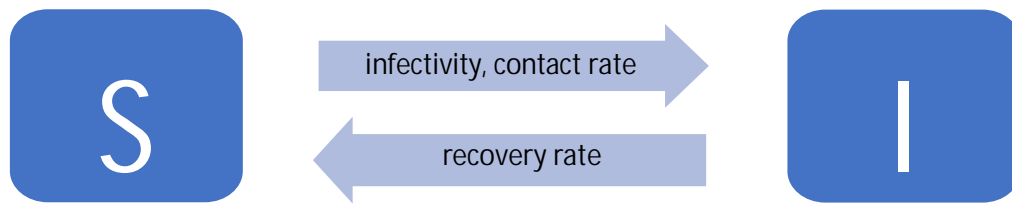
Figure 1. SIS model

The SIS model (see Figure 1) examines scenarios in which individuals have no immunity after contracting the disease, and upon recovery, they immediately return to the susceptible phase.

Mathematically, the situation can be described:

$$\frac{dS}{dt} = \Lambda - \frac{\beta SI}{S + I} - \mu S + \phi I \tag{1}$$

$$\frac{dI}{dt} = \frac{\beta SI}{S + I} - (\alpha + \mu + \phi)I \tag{2}$$

where the parameter Λ is the number of susceptible individuals, μ is the natural mortality rate of the population, β is the disease transmission coefficient, α is the disease-assisted mortality rate, and Φ is the rate of movement of an individual from one category to another and back. After adjustment, we obtain the population-wide equation written by Vargas (2011):

$$\frac{d}{dt}(S + I) = \Lambda - \mu(S + I) - \alpha I \tag{3}$$

The population size undergoes natural fluctuations over time and stabilizes at an equilibrium state in the absence of disease Λ/μ.

Vargas (2011) elucidates the SIR and SIRS epidemiological models (graphic representation in Figure 2) in which people possess either temporary or long-lasting immunity to infection and recovery. The SIR model involves susceptible and infected individuals coming into contact with each other and having a certain likelihood of becoming infected. In this instance, we observe the transition rate between the susceptible and infected states. Once healed, an individual in the infected category enters the cured category and remains there, having acquired full immunity to the illness. The SIRS model assumes only temporary immunity to the disease, which is determined by the parameter representing the duration. This model can be used, in practice, for seasonal illnesses such as influenza or COVID-19.
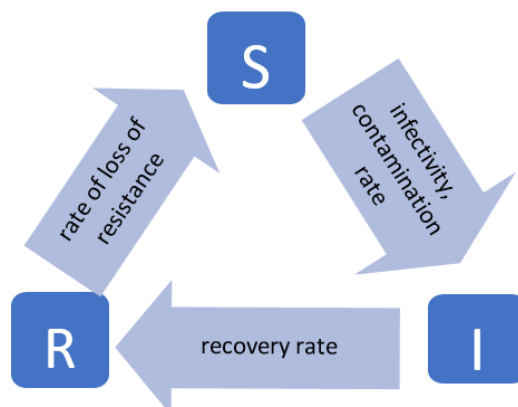
Figure 2: SIR model

The mathematical expression of each category is:

$$\frac{dS}{dt} = \Lambda - \frac{\beta SI}{S + I + R} - \mu S + \phi I \tag{4}$$

$$\frac{dI}{dt} = \frac{\beta SI}{S + I + R} - (\alpha + \mu + \phi)I \tag{5}$$

$$\frac{dR}{dt} = \kappa I - (\mu + \gamma)R \tag{6}$$

where parameters Λ, μ and β are positive constants and parameters α and γ are non-negative constants. Another assumption is that κ is a kind of constant rate of recovery of an individual and parameter γ is a constant rate of loss of immunity of an individual to the disease. The author describes time $1/\kappa$ as the mean average time of infection and time $1/\gamma$ as the mean average time of immunity. By summing these equations, a single differential equation can be obtained:

$$\frac{d}{dt}(S + I + R) = \Lambda - \mu(S + I + R) - \alpha I \tag{7}$$

Similar to equation (3), the total population size changes over time and converges to an equilibrium state in the absence of disease Λ/μ.

The SEIR model includes a category for those infected but not yet infectious, whereas the SIERS model assumes that those cured can lose immunity and become infectious gain (Camacho et al., 2020). One of the more comprehensive models for COVID-19 is SIDARTHE, comprising 8 states: Susceptible, Infected, Diagnosed, Ailing, Recognized, Threatened, Healed, Extinct (Higazy, 2020).

1.2. Game Theory in Epidemiology

Game theory is commonly used in epidemiology to investigate the tactical actions of individuals. In modeled scenarios of repeated games, individuals in a population select between strategies and adapt their strategies in subsequent rounds of the game based on their prior payoffs. Agent-based models enable the realistic simulation of diverse populations responding to various epidemic scenarios, assessing the decision-making strategies of individuals, their reliance on experience or peer influences.

Vaccination games serve as models that reflect the vaccination attitudes of individuals. Zhang et al. (2013) introduced a gaming scenario that involved three strategies: vaccination, self-protection, and laissez-faire. They found that this model can create the Braess paradox, in which a superior individual outcome results in an inferior societal outcome.

The significance of spreading information regarding the disease, vaccines, and individuals' attitudes is illustrated in a study by Kabir and Tanimoto (2019). The study integrates a two-layer model of the SIR/V-UA epidemic's spread into a metapopulation migration model for random walkers to investigate how individuals' information affects their access to vaccinations or their movement to a safer location. Players are divided into groups based on their health and vaccination status, each assigned its own payoff matrix. The susceptibility to disease varies by group, and the rate of contagion may decrease depending on available information. The

authors' conclusion is that information regarding disease and its spread is critical to the epidemic management process.

Della Marca et al. (2013) employs evolutionary game theory to simulate swift decision-making dynamics and rapid shifts in opinion on the SIR model. Meanwhile, (Okita et al., 2023) present a stochastic approach utilizing evolutionary game theory to model the spread of epidemics.

The impact of incomplete information on vaccine deferment was the topic of discussion in (Bhattacharyya & Bauch, 2011). The video game was developed in response to the behavior of individuals who postponed getting the H1N1 vaccine in 2009 because of limited information concerning the vaccine's adverse effects and inadequate testing. A comparable situation has emerged in the context of the COVID-19 pandemic, where divergent viewpoints and stances on vaccination have created divisive tendencies among the populace. The prevalent utilization of social media has played a significant role in fostering social division by disseminating official and unofficial information. The SIR epidemic model categorizes individuals based on their status as vaccinated or unvaccinated, which serves as the basis for describing the model's dynamics within this framework. Each game round spans 52 weeks, during which players may choose to get vaccinated or remain unvaccinated. Vaccination offers two weeks of protection.

Getting vaccinated is important for achieving group immunity, especially for unvaccinated individuals. For those who already have group immunity and are surrounded by vaccinated individuals, information obtained about vaccine safety from their environment reduces the hypothetical vaccination cost. The common approach is to "wait and see", leading players to delay vaccination. It should be noted that in both scenarios, approximately 20% of players choose not to get vaccinated at all.

Kuga and Tanimoto (2018) present a framework for comparing two imprecise methods for safeguarding against infectious illnesses: vaccination, which provides partial protection, and mask-wearing. Technical terms are explained on their first use to assist readers in comprehension. The study utilizes the SIR (Susceptible, Infectious, Recovered) model to create a repeated game that spans multiple rounds, with each round ending after all individuals have recovered. The text maintains a formal register, precise language, and objective tone while adhering to standard style guides and conventions. The study utilizes the SIR (Susceptible, Infectious, Recovered) model to create a repeated game that spans multiple rounds, with each round ending after all individuals have recovered. After each round, an individual's strategy is influenced by the strategy of a randomly encountered individual, the average of chosen strategies in the population, or random choice. The payoff function is determined by the cost of infection (if infected) and the cost of vaccination. Two metrics were used to compare outcomes: vaccine efficacy and mask effectiveness. The results suggest that suboptimal vaccination is more effective in managing a pandemic when vaccine effectiveness and mask efficacy are equivalent.

The scientific community is investigating the feasibility of predicting or affecting the increase in vaccine deferrals. The study intends to enhance comprehension regarding the probable consequences of vaccine deferral approaches. Bhattacharyya and Bauch's (2010) research introduced a game regarding voluntary vaccination postponements against childhood

illnesses, based on age and perceived risk. The game provides three choices: vaccination, deferral, or non-vaccination. As infection rates rise, those who defer vaccination and those who refuse it entirely reach a balance, as highlighted by the game's results. This tends to happen when the cost of vaccination is high or the risk of contracting the disease is low among the first age group. As a result, people tend to postpone getting vaccinated until the second age group, when vaccination costs or disease risks are lower for younger children. Earlier vaccination becomes a more favorable option as the number of infected individuals and their risk of infecting others increase. Consequently, this reduces the number of cases while increasing instances of deferral, resulting in an increase in infected individuals.

1.3. Epidemic Models in NetLogo

NetLogo (Wilensky, 1998) is a platform used to implement agent-based models in various application areas, including epidemiology:

- *EpiDEM Basic* model (Yang & Wilensky, 2011) simulates the spread of a disease in a closed population. The model is based on the Kermack-McKendrick model of SIR in a closed population over time. In the model, agents move randomly around the world, and when an infected agent encounters a susceptible agent, there is a probability that the uninfected agent will become infected.

- *Epidemic Travel and Control* model (Rand & Wilensky, 2008) simulates the spread of a disease in a semi-confined population with additional elements such as travel, isolation, quarantine, vaccination and links between individuals.

- *Spread of Diseases* model (Rand & Wilensky, 2008) deals with the spread of diseases in different settings and environments. Its main objective is to study what assumptions and interactions between agents can fundamentally affect the results of the model.

- *Virus* model (Wilensky, 1998) simulates the transmission and spread of a virus in a human population. Agents move randomly and are generated with random ages. Agents can die and reproduce.

- *Virus on Network* model (Stonedahl & Wilensky, 2008) simulates the spread of a computer network infection, with the ability to experiment with both network and virus parameters.

2. Methodology

The objective is to showcase the integration of game theory and agent-based modeling concepts in an epidemiological model using NetLogo.

The model is a multi-round, iterative, and symmetrical vaccination game with incomplete information. Players select their strategy based on a comparison of the cost of the disease and vaccination. The cost is influenced by the epidemic course as well as the decisions of adjacent players, and players can opt to vaccinate or not.
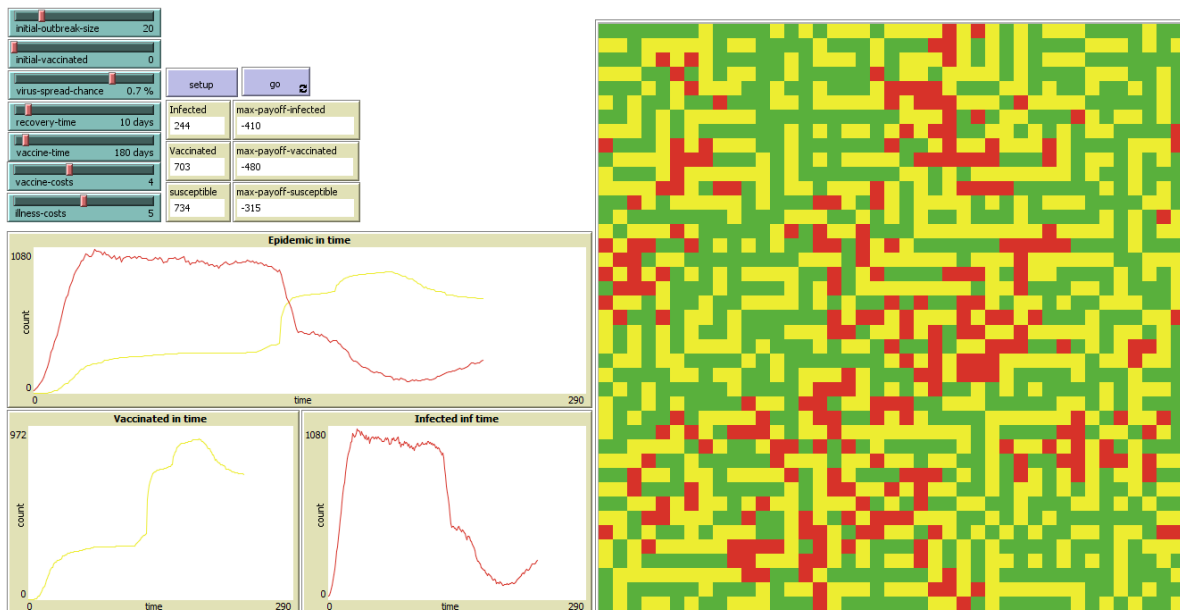
Figure 3: Netlogo user interface

The simulation is regulated by input parameters in the user interface (see Figure 3), facilitating the simulation of varied scenarios and diseases. Seven parameters are defined as follows:

- The *initial outbreak size* parameter denotes the count of persons infected at the onset of a certain epidemic. Parameter takes values between 1 to 100.

- The *initial vaccinated* parameter sets the number of people vaccinated against the said disease prior to the outbreak. Vaccinated individuals are capable of resisting infection and can help decrease the spread of diseases by raising awareness about vaccines in their community. Parameter takes values between 1 to 100.

- The parameter for *virus spread chance* denotes the percentage probability of transmission from an infected person to a susceptible person. Higher probability leads to faster disease spread among the population. Parameter takes values between 0 to 1.

- The *recovery time* denotes the duration (in days) it takes for an infected person to recuperate and cease to spread the disease. Parameter takes values between 1 to 100.

- The *vaccine time* parameter specifies the length of time (in days) that a vaccinated person is safeguarded against contracting the disease. Parameter takes values between 0 to 2,100.

- The *vaccine costs* parameter determines the expenses incurred in inoculating an individual against the disease, including financial, time, or other elements that factor into individuals' willingness to get vaccinated. Costs are given as dimensionless ratios ranging from 1 to 10.

- The *illness-costs* parameter is determined by expenses linked with the treatment and care of the infected individual. Such expenses comprise of medical care, hospitalization, isolation, and other factors connected to the course and treatment of the disease. Costs are given as dimensionless ratios ranging from 1 to 10.

The model enables the tracking of infection rates, player strategy adoption, and maximum player payoffs across all three states. Each player operates under specific parameters that dictate its current state. The players are placed within a square grid, with each player having a

maximum of eight neighboring players. The simulation involves 1,681 players and continues for 2,000 rounds, or until the epidemic has been eradicated. A subsequent version of the model also monitors mortality rates, reinfection rates, and vaccination rates. The players' decision to alter their strategy reflects the number of deaths. The strategy-selection procedure determines the players' strategy. Initially, the infection-risk parameter is calculated, indicating the risk of infection. The original calculation (8), from (Liu & Shang, 2020), appears as follows:

$$\lambda_i = \beta * \frac{N_i^{non}}{N_i^{vac} + N_i^{non}} \tag{8}$$

where λ_i is the risk of infection, β the transmission rate, N_i^{non} the number of unvaccinated neighbors and N_i^{vac} the number of vaccinated neighbours. To address the gravity of the situation, relevant data on the quantity of affected neighbours has been incorporated into the computation, resulting in the following equation (9):

$$\lambda_i^* = (\beta + \frac{N_i^{noninf}}{N_i^{inf} + N_i^{noninf}}) * \frac{N_i^{non}}{N_i^{vac} + N_i^{non}} \tag{9}$$

where N_i^{noninf} is the number of healthy neighbours and N_i^{inf} is the number of infected neighbours. Next, the cost of changing strategy, i.e., vaccinating and the cost of not vaccinating, are calculated by equation (10) and (11).

$$cost - change = (1 + \sigma_i) * r_c \tag{10}$$

$$cost - unchanged = (1 - \sigma_i) * \lambda_i \tag{11}$$

where σi is a decision value of 1 for vaccination, -1 for refusal, r_c is the cost ratio. Based on the comparison, the player decides whether or not it is good for him to be vaccinated in a given situation.

3. Results

Three experiments were conducted to demonstrate the benefits of an agent-based model as a tool for capturing the impacts of individuals' decision making in epidemic situations. The experiments aimed to address three questions related to the model.

- *Question 1:* Do the costs of illness and vaccination influence players' decision-making?
- *Question 2:* Is there a group of players who may decide against getting vaccinated during the game due to the associated cost?
- *Question 3:* Is there a correlation between the number of vaccinated players and the transmission of infection through sweat?

3.1. Question 1 – Experiment 1

The initial study aimed to examine whether lowering the vaccine/disease cost ratio, by reducing the expense of vaccination, positively impacts the population's vaccination coverage. The simulation findings support the hypothesis that individuals are inclined to vaccinate more frequently when the costs of vaccination are lower. In certain instances, the

vaccination rate is either equivalent or higher when the percentage of infectivity is lower than the simulation with a greater percentage of infectivity.

It should be noted that the simulation results support the hypothesis, which leads to players opting for a more frequent vaccination strategy in circumstances where the cost is lower. However, in certain instances, the vaccination rate appears to be higher or equivalent for simulations with lower infectivity percentages, as opposed to those with higher rates. This phenomenon may arise from the comparison of the average number of vaccinated players, coupled with the limited number of simulation repetitions. In addition, the duration of the games also reflected the number of vaccinated players.

Table 1. Data from the experiment

| Cost ratio | Percentage chances of infection | | | | | | | | | |
| | 0.7 | | 0.6 | | 0.5 | | 0.4 | | 0.3 | |
	Number of vaccinated	Vaccinated %	Number of vaccinated	Vaccinated %	Number of vaccinated	Vaccinated %	Number of vaccinated	Vaccinated %	Number of vaccinated	Vaccinated %
1	315	0.19	317	0.19	312	0.18	316	0.19	305	0.18
0.8	494	0.29	493	0.29	491	0.29	485	0.29	415	0.24
0.6	683	0.41	681	0.41	672	0.40	677	0.40	570	0.34
0.4	826	0.49	805	0.48	786	0.48	745	0.44	646	0.38
0.2	990	0.59	869	0.51	845	0.50	777	0.46	742	0.44
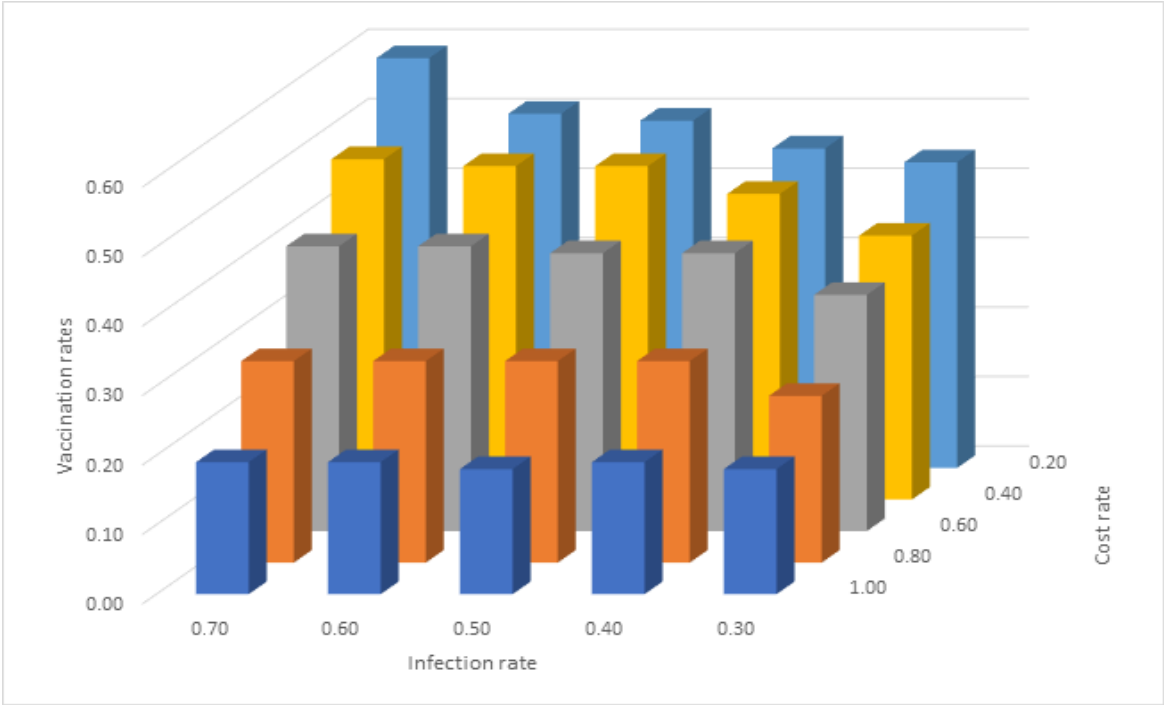
Figure 4. Dependence of the cost ratio on the percentage infection rate

The 3D plot (see Figure 4) shows the dependence of the number of vaccinated on the vaccination cost/vaccination ratios for different percentage chances of being infected. This experiment verified results article (Liu & Shang, 2020) and the values of the experiment outputs in Table 1.

3.2. Question 2 – Experiment 2

In the experiment, players will be given lifetime protection by vaccination, so at the end of the game players will remain in the susceptible and infected states, i.e. players who have not been vaccinated throughout the game. Two scenarios will be played – 2,000 rounds and 364 rounds. The cost settings are as follows:

$$r_{vac} \ll r_{inf}$$

$$r_{vac} > r_{inf}$$

where r_{vac} are vaccination costs r_{inf} are infection costs. Setting the vaccine cost much lower than the disease cost, the results for 2,000 and 364 days came out similarly: 25% and 27%. Setting the disease cost much lower than the vaccine cost, the simulations for 2,000 and 364 days came out similarly: 82% and 85%. The simulations with much lower vaccine costs approach values around 20%, but the second version of the simulation does not. This experiment verified results from (Bhattacharyya & Bauch, 2011).
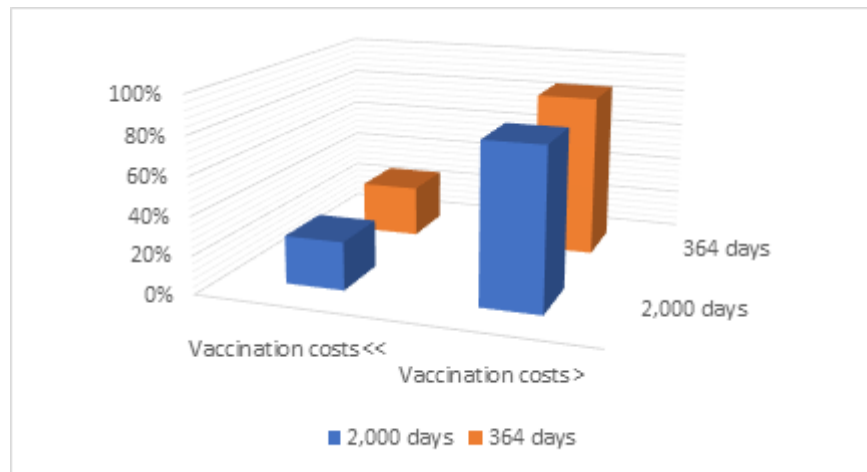
Figure 5. Nonvaccinated players

Are there unvaccinated players who are not impacted by its cost during gameplay? Results for both 2,000 and 364 days were similar at 25% and 27%, respectively, when setting vaccine cost lower than disease cost. Likewise, results for both 2,000 and 364 days were similar at 82% and 85%, respectively, when setting disease cost lower than vaccine cost in the simulation. Likewise, results for both 2,000 and 364 days were similar at 82% and 85%, respectively, when setting disease cost lower than vaccine cost in the simulation. The simulations with significantly reduced vaccine costs converge to values approximately at 20%, whereas the second version of the simulation does not display the same trend. The graphic representation shows Figure 5.

3.3. Question 3 - Experiment 3

For our experiment, we have established that the cost of illness is equal to the cost of vaccination in the model. Final protection will be given through vaccination since more players can be vulnerable to the disease when the protection expires. The length of protection is set to 180 days. Our experiment has proven that the number of vaccinated individuals

fluctuates cyclically, depending on the number of infected individuals. The rate of contagion influences the initial outbreak of the epidemic and determines the maximum number of players who can be vaccinated. It also has a minor impact on the amplitude of the player count. Moreover, the risk of infection grows along with the number of infected individuals. As a result, the cost of illness escalates, which pressures the players to adopt a strategy of not getting vaccinated. Increasing the number of vaccinated players decreases vaccination costs and prevents the spread of the virus. These findings align with those of Bhattacharyya and Bauch (2010). The blue line reflects a contagion rate of 0.5, orange at 0.6, and grey at 0.7.
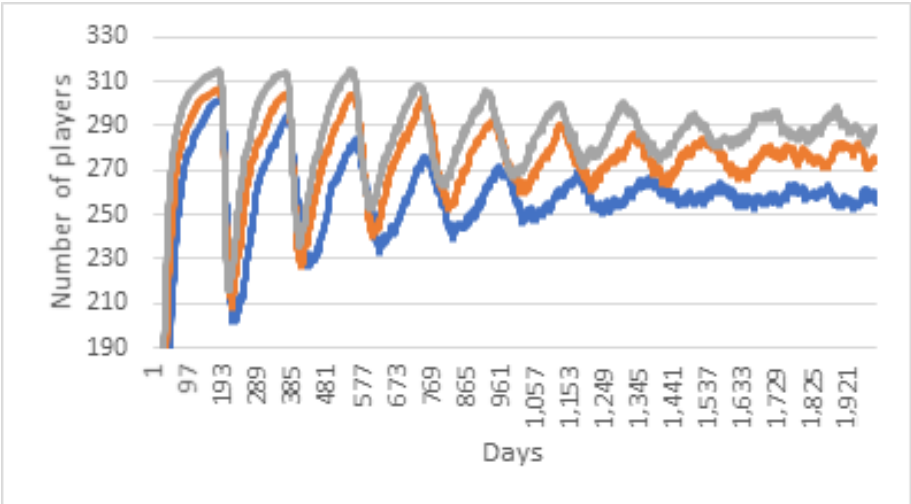
Figure 6. Number of vaccinated players

The infectivity rate has a significant impact on the initial outbreak of the epidemic and determines the maximum number of vaccinated players. It also has a slight influence on the amplitude of the player count. At the initial stage, there is a larger amplitude of fluctuation, which gradually decreases over time. However, the number of vaccinations does not fully stabilize the situation. As the number of infected individuals rises, the risk of infection also increases, leading to higher costs of illness. This compels players to opt for the non-vaccination strategy. The study confirmed that the number of vaccination strategies selected depends on the current number of infected players and follows a cyclical pattern (see Figure 6).

5. Conclusions

Based on available information, researchers developed a NetLogo model that merges epidemiology and game theory. Technical term abbreviations are explained when first used. The model simulates a symmetric and iterative vaccination game with imperfect information, where players select a strategy based on a cost comparison between disease and vaccination. Citations adhere to a consistent style guide, and quotes are clearly marked. The epidemic course and neighboring players' decisions affect the cost. The text uses passive tone and formal register, with precise word choice to ensure grammatical correctness. Players choose between two strategies: vaccination or no vaccination. The model permits the simulation of various scenarios and diseases, as input parameters are insufficiently controlled. This enables the tracking of the progression of infection levels, number of players following a specific

strategy, and maximum payouts in all three states. For model validation, three experiments were conducted with published scientific articles as a reference. The results of two of these experiments were consistent with our expectations. The model rejects the use of game theory in epidemiology by simulating individuals' decision making according to the disease progression. It has the potential to expand to monitor reinfections and revaccinations and consider disease severity when determining the subjective cost and its impact on individuals' decision making.

Conflict of interest: none.

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The Impact of Pandemic and Energy Crisis on the Financial Performance of Small and Medium-Sized Enterprises in European Countries

Pavel DANIHEL* and Jana KAJANOVÁ

Comenius University Bratislava, Bratislava, Slovak Republic; danihel7@uniba.sk; kajanova8@uniba.sk

* Corresponding author: danihel7@uniba.sk

Abstract: In an effort to mitigate the effects of the pandemic and the recent energy price shock, the world economies initiated recovery packages to support economic growth as part of their recovery plans. SMEs have the potential to be a vital part supporting the given process. Through their entrepreneurial innovativeness, SMEs are the carriers of innovations that can stimulate economic growth. For this reason, it is necessary that the efforts of national economies to support economic recovery take into account the potential and simultaneously the vulnerability of SMEs in times of crisis. By creating suitable conditions for the revitalization of financial resources, in order to improve the financial health of SMEs, national economies can achieve their use as a catalyst for economic recovery. An essential part of maximizing the obtained effect will be an understanding of the impact of both crises on the financial health and performance of SMEs, which can be insightful in the case of setting up business support as a part of national recovery plans or as the preparation of entrepreneurs to reduce the impact of the crisis to their businesses.

Keywords: small and medium-sized enterprises; SMEs; covid-19; energy crisis; financial health; performance

1. Introduction

The constant need to adapt the business model to better reflect the current situation was the mandatory rule of success for SMEs in the past as it is today. Technological progress has seen a great leap towards digitalization and digitization over the past decade. For most of the companies, today's communication with clients and business partners is easier, faster and more transparent. Business models are also highly affected by this phenomenom, focusing mainly on the goal to communicate, manufacture, store and distribute with cost minimization. There are SMEs that have their product fully produced at one business partner, have it stored at another and then use the third one for distribution, or use their own capabilities and resources. At the same time, they do not have to meet with their partners in person on a regular basis, but solve the vast majority of tasks and orders online through business platforms or other internet-based interactive technologies (Neghina et al., 2019). Such a high level of networking between companies was established long before the outbreak of covid-19. SMEs have already proven their high level of adaptability due to scientific and technological progress. With the ongoing

pandemic, this ability has been fully tested again. SMEs are forced to search for new survival strategies to overcome against the negative impacts of the pandemic on their financial health (Belas et al., 2022).

Covid-19 has been hitting the entire business activity for several years. The post-pandemic world would witness the large enterprises use any means necessary to reclaim their margins and profit. Such an effort can threaten SMEs in losing their profitability and market share. In order to reclaim their space in the market, SMEs will have to rediscover their entrepreneurial innovativeness. By finding new ways of business solutions with the aim of expanding beyond the already existing added value to goods and services, they can ensure sufficient demand for the financing needs of their business model (Zutshi et al., 2021).

Despite the fact that the negative effects caused by the covid-19 pandemic are undeniable, there are various aspects of business where SMEs have already been able to adapt to such an extent of effectiveness that they have stabilized their financial situation and even strengthened their position in the market (Huang et al., 2022). Therefore, this study is aimed to examine not only the negative aspects of the pandemic, but the positive outcomes as well.

The second negative, unforeseeable phenomenon affecting SMEs in Slovakia and abroad is the Russian-Ukrainian war, causing a problematic economic situation for the EU27 countries and the United Kingdom. The current situation has led to the interruption of gas supply from Russia, which has caused a large-scale increase in energy costs (Roeger & Welfens, 2022). In our research, we will look at the energy crisis in the same aspect as the covid-19 pandemic, with both positive and negative effects for SMEs. Based on the background, the aim of this study is to provide a deeper insight into the impact of the pandemic and the energy crisis on the financial health and performance of SMEs.

Since the beginning of the COVID-19 pandemic, there have been a number of different studies that have examined the impact of the adverse situation on different sectors of the economy. International institutions and scientific teams produce economic and statistical reports for the governments of individual states in order to ensure support for the development of adequate measures to mitigate the consequences of the crisis (Espitia et al., 2020; UNCTAD, 2020; WTO, 2020). Many countries despite achieving significant losses, decline of the national economy and deficits in the state budget, avoided possible bankruptcy thanks to appropriately adopted political measures (Alves et al., 2020; Virglerová et al., 2020; Wójcik & Loannou, 2020). After several waves of covid-19 and a significant number of measures taken, the effectiveness of which we will only be able to observe in the following years of the post-pandemic period, the world economies are facing a new crisis. The Russian-Ukrainian conflict, starting in October 2022, represents another event that will significantly change the economies of individual states at both the macroeconomic and microeconomic levels (Siddiqui, 2022).

One of the most significant consequences of the currently ongoing conflict in the context of economic impacts is the interruption of Russian gas supplies to the EU. The stoppage of supplies caused an enormous increase in gas prices starting around the summer of 2022 (Roeger & Welfens, 2022). In the countries of EU, the electricity market is dominated by the merit-order approach, affecting the price of electricity, based on the merit principle, in which

dispatchable power plants enter the market in the order of their marginal costs to cover the residual load, i.e. the difference of load and renewable generation (Trebbien et al., 2022). Using this approach caused an excessively high increase in electricity prices (Roeger & Welfens, 2022).

Due to their key influence on the national economy, SMEs are the area most affected by the consequences of both pandemic and energy crisis. Most national economies are fully aware of the vulnerability of SMEs and for this reason have included direct support for the sector in their national recovery plans. The budget of the recovery plans of most European countries is mainly financed by the funds of the NextGenerationEU initiative, which is focused mainly on green recovery, associated with the application of digitalization and digitization to the public and business sectors as a response to the pandemic crisis (OECD, 2022). Slovakia, as an EU member country, uses the NextGenerationEU funds to meet the set goals. The national recovery plan of Slovakia uses a certain part of the funds for direct and indirect support of SMEs. As an example, we can use one of the plan's components, including business support through directly allocated financial resources for SMEs. An example of indirect financial support is the targeted reduction of costs for entrepreneurs using the application of digitalization in the public sector (Plán obnovy, 2021). Within the countries of the European Union, we can notice similar trends in the content of recovery plans. However, the share of funds devoted to direct or indirect support of SMEs is worrying (OECD, 2022). Holienka et al. (2022) focused in their research on the positive effect of sufficient funds as one of the main factors increasing entrepreneurial self-confidence and willingness to take risks, which ultimately motivate new entrepreneurs in establishing their business.

To better understand the impact of both covid-19 pandemic and recently started Russian-Ukrainian war, which led to the energy crisis, we will investigate how these events contributed and will contribute to the development of the financial health of SMEs. This study includes views, perspectives and strategies from different countries. As part of the investigation of the impact of covid-19 on the stock market, (Ashraf, 2021) used Pearson's correlation in his research using equivalent variables defined as stock market returns and the development of countries' covid-19 confirmed cases. Research observed strong negative correlation between the variables. We consider the correlation evaluation using the number of confirmed positive cases as a potentially interesting variable that can also be used to assess the impact of covid in other areas of the economy. For this reason, our research addresses this research gap and uses the calculation of the correlation with the number of new confirmed cases in connection with the use of the Value added metric as a variable determining the assessment of the performance development of SMEs in the countries of the European Union.

2. Methodology

In the context of assessing and understanding the impact of covid-19 and the enormous increase in energy prices caused by the Russian-Ukrainian war, we conducted a large-scale investigation based on the research objective to determine how these events contributed to the development of the financial health of SMEs in different countries. In order to obtain the necessary data for the implementation of the research, we used both qualitative and quantitative methods based on the knowledge resulted from the broader context of the given

topic and also from the financial results of selected international companies. By using the both approaches to data acquisition, we were able to gain a broader view of the research topic and at the same time offer a basis for expanding research in the future. For the most reliable information, we compared the opinions of several foreign experts and obtained data sources at the international level.

In the empirical part of the research, we focused more closely on evaluating the impact of the covid-19 pandemic on the performance of SMEs by calculating the correlation through the Pearson coefficient. This method of determining intercorrelation is most commonly used for numerical variables and does not take into account the dependence of the variables, but treats them as equivalent (Muhaidat et al., 2022).

3. Results

In this research chapter, we will focus more on the application of theoretical knowledge to specific statistical and research data.

3.1. The Impact of Covid and Energy Price Shock to SMEs Performance

In the following chart, we can see the development of the added value of SMEs in the countries of the European Union (EU27) over the last 10 years, covering the time span before and after the covid-19 outbreak. In the monitored period, micro, small and medium-sized enterprises have approximately the same share in the distribution of added value for the entire SME sector
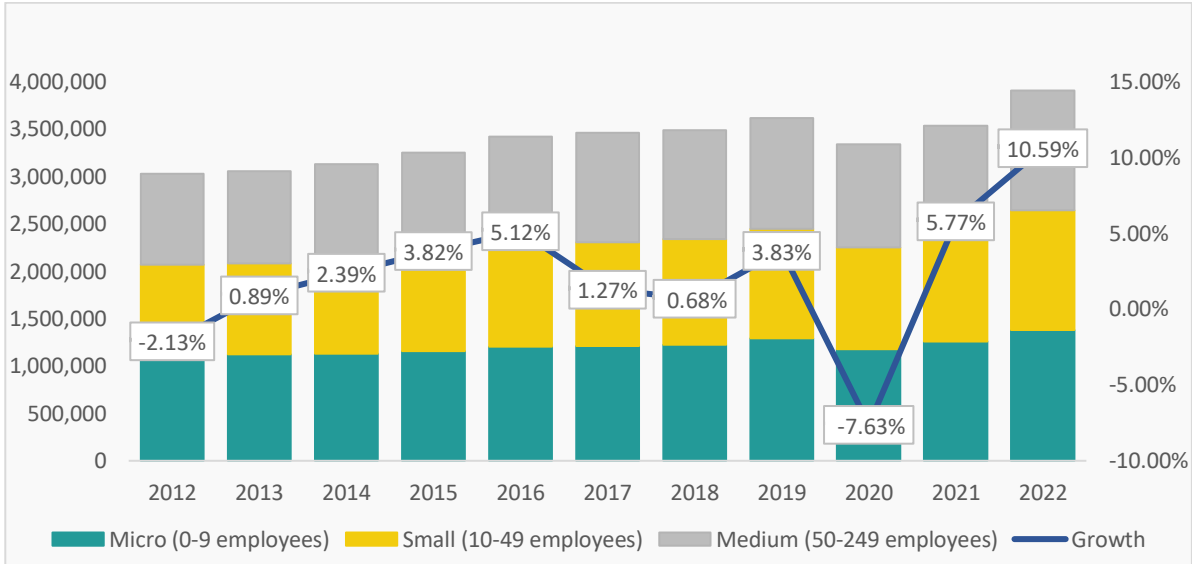
Figure 1. Value added by SMEs in EU27 countries from 2012 to 2022 [M€] (Statista, 2022)

As we can notice, continuous growth of value added in EU27 countries occurs in the pre-covid period in seven consecutive years. In 2020, after the outbreak of covid-19, SMEs in EU27 experienced a sharp decline. In the following year, the value added by SMEs again achieved growth, which was supported in 2022 by a noticeable 10.59%.

For a deeper assessment of the impact of the coivd-19 pandemic on the SMEs performance in European countries, we decided to assess the occurrence of a correlation between the covid-19 pandemic and the development of the added value of SMEs. For the given calculation, the variable y represents the added value in selected 19 European countries for the period 2020-2022. The variables x are represented by the annual development of the number of new covid-19 cases in individual countries. The following table shows the values of added value achieved in successive years in the countries included in the study.

It should be noted that the study is not based on the full number of EU27 countries. Due to the unavailability of the dataset for some of the countries, our research includes an extensive grouping of selected EU countries, depicted in Table 1.

Table 1. Value added by SMEs in selected European Union countries from 2020 to 2022 [M€] (Statista, 2022)

Country	2020	2021	2022	Avg. YoY growth [%]
Austria	109,697	116,912	125,500	6.96
Belgium	135,306	156,082	164,040	10.20
Bulgaria	20,173	21,668	23,984	9.01
Croatia	15,176	17,148	18,400	10.10
Cyprus	7,210	7,947	8,599	9.20
Czechia	63,138	68,339	74,044	8.29
Estonia	10,963	12,395	13,211	9.79
Finland	62,716	65,177	67,141	3.47
Germany	875,951	923,983	1,007,518	7.26
Greece	27,893	33,612	36,716	14.87
Ireland	87,401	91,792	99,241	6.57
Latvia	9,268	10,391	11,325	10.54
Lithuania	16,538	18,388	20,154	10.35
Malta	4,610	5,216	6,255	16.50
Netherlands	252,219	272,011	284,369	6.19
Portugal	57,571	61,155	67,007	7.89
Romania	45,870	52,000	57,130	11.58
Slovakia	23,668	24,531	27,542	7.92
Slovenia	16,870	18,608	19,690	8.06

The development of Value added reached a constant increase for selected European countries during the observed period. Despite the crisis caused by the covid-19 pandemic and later the energy price shock, the SMEs managed to increase Value added in 2021. This trend continued in 2022. The average year-on-year increase for all selected countries in the monitored period amounts to 9.20%. Malta recorded the largest average YoY increase by a wide margin. The largest average year-on-year increase in monetary units was achieved by Germany, which increased the produced Value added by an average of 65,784 million euros. The Slovak Republic managed to achieve an average YoY increase just below the average of selected European countries with a value of 7.92%. The Czech Republic, which is a neighboring country of Slovakia and also a member of the V4, achieved a slightly better performance with 8.29%.

Table 2. Annual balance of new covid-19 cases in selected European Union countries from 2020 to 2022 (ECDC, 2022)

Country	2020	2021	2022	Avg. YoY growth [%]
Austria	357,410	914,787	4,129,965	253.70
Belgium	650,040	1,475,862	2,481,394	97.59
Bulgaria	202,266	544,842	528,373	83.17
Croatia	210,837	504,408	529,447	72.10
Cyprus	22,651	144,176	429,470	367.19
Czechia	733,479	1,752,631	1,666,887	67.02
Estonia	28,393	213,738	364,137	361.57
Finland	36,681	241,354	1,057,283	448.02
Germany	1,754,432	5,440,699	28,092,559	313.23
Greece	138,850	1,072,003	3,924,347	469.06
Ireland	91,779	696,780	881,818	342.87
Latvia	40,904	235,770	672,578	330.83
Lithuania	147,861	378,766	739,358	125.68
Malta	12,774	39,696	62,773	134.44
Netherlands	795,538	2,336,036	5,363,131	161.61
Portugal	400,606	1,013,820	4,100,056	228.74
Romania	632,431	1,176,628	1,437,521	54.11
Slovakia	184,508	1,090,159	1,260,887	253.25
Slovenia	124,034	341,757	762,426	149.31

The number of new cases of covid-19 reached a significant year-on-year increase in 2020-2022. As we can see in Table 2, in 2020 there were the fewest confirmed new cases of the entire monitored period. It remains interesting that the year 2020 is generally considered to be the period when the anti-epidemic measures among the states were the strictest and the public was the most concerned. The average year-on-year increase for all selected countries in the monitored period is 227.03%. Greece achieved the largest average annual increase with 448.02%. The largest average year-on-year increase expressed in the number of infected people was achieved by Germany with more than 13 million cases. Slovakia achieved a slightly higher YoY increase compared to the average value of selected European countries. Compared to the Czech Republic, Slovakia performed worse year-on-year. However, at the beginning of the pandemic, there were significantly fewer new cases. We can observe a rapid increase in the number of new cases of the covid-19 pandemic in Slovakia starting in year 2021.

It should be noted that the analysis is limited by the downloadable data provided from ecdc.europa.eu, which contains the number of new cases of covid-19 infection only up to October 2022. We decided to consider this data limitation for the year 2022 as a full period due to a significant year-on-year increase in the number of new cases and a low impact on the overall result of the calculation. The data used in table 1 and table 2 represent the input values for the correlation, aimed at assessing the interrelationship of the impact of the covid-19 pandemic on the performance of SMEs in the countries of the European Union. We use the Pearson Correlation Coefficient for our calculation. In the following picture we can see the details of the correlation calculation with the selected data.

Result Details & Calculation

X Values
$\sum = 84663796$
Mean = 1485329.754
$\sum(X - M_x)^2 = SS_x = 811339668869783$

Y Values
$\sum = 5951459$
Mean = 104411.561
$\sum(Y - M_y)^2 = SS_y = 2427159319770.04$

X and Y Combined
$N = 57$
$\sum(X - M_x)(Y - M_y) = 31220563897520.9$

R Calculation
$r = \sum((X - M_y)(Y - M_x)) / \sqrt{((SS_x)(SS_y))}$

$r = 31220563897520.9 / \sqrt{((811339668869783)(2427159319770.04))}$
$= 0.7035$

Meta Numerics (cross-check)
$r = 0.7035$
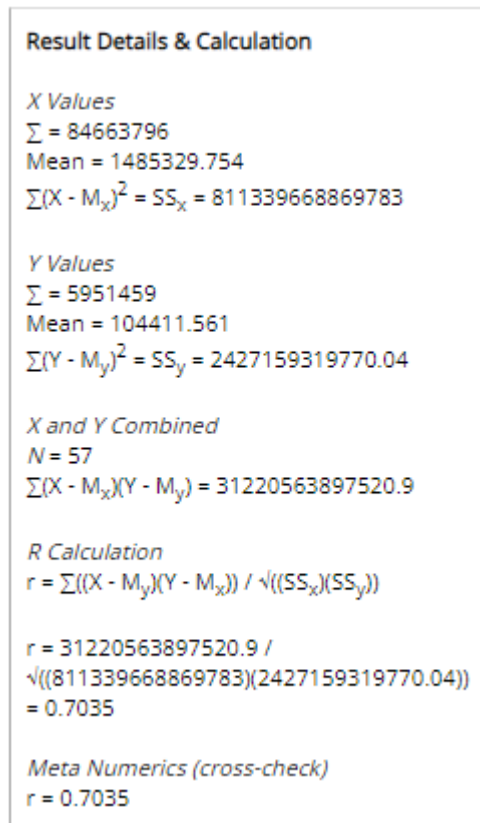
Figure 2. Calculation of Pearson correlation with selected x and y variables

The resulting R score reaches a value of 0.7035, which represents a moderate positive correlation. That means there is a tendency for x variables to achieve high scores with y variables. The value of R2, the coefficient of determination, is 0.4949. To test the significance of our results, we proceeded to test the p-value with a significance level of 0.05. With the resulting R score of 0.7035 and sample size (n) of 57, the p-value reaches the value < 0.00001. Since the p-value < α, H0 is rejected. To better summarize the results, Table 3 follows.

Table 3. Correlation results summary

R score	R2 score	P-value	Sample size
0.7035	0.4949	0.00001	57

Interesting aspects of the correlation of covid with SME performance is the development of the disease during the monitored years. The number of new confirmed cases has increased annually in most countries. One of the reasons is the different variants of covid-19 during the course of the disease. In October 2020, we reported the first cases of the delta variant, also referred to as B.1.617. The delta variant of covid-19 was significantly more infectious than previous versions. The assumption of being infected with the virus has subsequently increased, especially for people under the age of 50 (WHO, 2022). In February 2021, a new variant was discovered, named by WHO as "Omicron variant". This new version of covid includes increased transmissibility, infectiousness and immune escape. It has been observed that the reinfection risk from the Omicron variant of the SARS-CoV-2 virus is substantially higher than from the previously identified variants. Based on the mentioned facts, most of

the countries of the European Union recorded a record number of new cases of covid-19, as it follows from the data we used to calculate the correlation. Despite the high infectivity, the delta and omicron variants are described as less severe with a milder and shorter course (Khajotia, 2022).

We are aware of the fact that, despite the high number of new confirmed cases of covid-19, value added metric for selected 19 countries of the European Union recorded a significant year-on-year increase. Based on the input data for our research, we consider the year 2020, which was at the very beginning of the pandemic, as the period when the crisis affected the performance of SMEs the most. In 2021 and 2022, value added started to grow again despite the increasing number of confirmed positive cases. One of the reasons may be the relaxation of restrictions, the consequence of which in previous years was a significant limitation of business. At the same time, as a response to the pandemic, the states developed national recovery plans, some components of which in 2022 gradually began to fulfill their function of business support by providing financial resources for SMEs. The initiative of the European Union, NextGenerationEU, also played its role with the aim of supporting entrepreneurship and economic recovery through sustainability and digitalization. Last but not least, through their entrepreneurial innovativeness, SMEs explored new possibilities for carrying out their business activities. As an example, the significant expansion of working from home, known as home-office, increased the adaptability of SMEs in the context of the modification of the business model as an answer to the crisis.

3.2. The Impact of Covid and Energy Price Shock to SMEs Financial Health

The outbreak of the covid-19 pandemic has had a profound impact on the financial health of SMEs. As a result of the sudden drop in revenues, the liquidity of the affected companies gradually decreased. The research published under the responsibility of the Secretary-General of the OECD, indicated that in the absence of goverment intervertion, 20% of firms during crisis are vulnerable to exhaust their liquidity after one month, 30% after two months and close to 40% after three months (OECD, 2020). Kalemli-Ozcan et al. (2020) estimated that SME failure rates due to the Covid-19 pandemic will increase by 60-130% depending on the countries selected. The study also examines the specific SME sectors most affected by the crisis. Among the most vulnerable sectors are Accom. & Food service, Arts, Ent., & Recreation and Mining. Kamaldeep (2021) investigated the expectations of SMEs to effectively manage the ongoing pandemic. From the examined sample, 29% of SMEs willingly try to enter new markets or develop new products and services, and more than 44% are looking for a new way of financing in order to revitalize their financial resources with the application of innovative financial management strategy.

The search for new innovative business opportunities and access to new markets have reduced the negative impact of the pandemic on many SMEs. Some businesses have been able to use the restrictions associated with trying to limit the spread of the infection to their advantage. Social distancing measures have led many SMEs to accelerate the transition to digital platforms as a new way to reach customers. SMEs that were able to effectively use the advantages offered by digital platforms could expand their market share thanks to this

competitive advantage. Di Maria et al. (2023) investigated how Italian fashion brands were able to use the impact of covid-19 to strengthen their relationship with customers. Using the advantages that e-commerce provides to entrepreneurs, they filled their websites with the promotion of new innovative protective masks. Thanks to the refined content, the company was able to present its customers with the offered quality and possibilities associated with the new product. They supplemented the sales support with the initiative of communication via Whatsapp, during which the seller in the store can present the offered products through an activated video call. Another example of positive adaptation is the food industry, on which covid-19 had a devastating impact. Social distancing has led to the expansion of online food deliveries, which in the conditions of the risk of infection brought a relatively safe possibility of using the restaurant offer without the need to visit the establishment. Due to the covid pandemic, many restaurants that did not use digital services until then have reached out to the possibilities of online ordering of their meals for customers (Li et al., 2022).

4. Discussion

While some SMEs have been able to adapt and survive, many others have had to close their doors or reduce their operations significantly. Determining the exact values of the number of SMEs that were forced to cease their activities due to the consequences of covid-19 is prevented by the fact that different countries of the world do not provide comprehensive statistics of the impact of the pandemic on their business sector in precise numbers that would be measurable and at the same time internationally comparable. The study Gourinchas et al. (2020) prepared the comparison of aggregate SME failure rate during the non-covid period and after the impact of the pandemic for selected countries of the European Union. From the original value of 9%, the SME failure rate would increase to approximately double the value of 18% in 2020 if the government did not take measures. However, in reality, many governments have provided quite significant support to the business sector. Measures representing less significant business support include, for example, deferral of taxes, rent and interest reduction. On the contrary, cash grants can significantly reduce the rate of failure of SMEs. According to estimates, a grant equivalent to 15 percent of a firm's annual wages in the current year would reduce business failure to 12.40% from a projected 18% without government intervention.

The impact on the financial health of SMEs can also be observed in the case of the second current crisis, caused by a sudden energy price shock. The increase in energy prices affects SMEs in several ways. In general, we can say that an increase in operational costs reduces the achieved profitability. Paying a higher bills for energy can severely disrupt liquidity of many businesses due to the necessity of paying costs earlier than recieved payment from the customers (Bongalonta & Bongalonta, 2022). Businesses that are able to deal with an increased operating cost, reduced liquidity and negatively impacted Cash flow, can gain a significant competitive advantage. SMEs unable to effectively adapt to enormously increased energy prices can also lose the ability to effectively invest in business opportunities (Hussain et al., 2022). This fact results primarily from the need to spend financial resources to compensate for increased electricity prices or to mitigate the effect of price shock with an

investment in energy-efficient technology with potential savings in the long term. One of the effective ways to cope with the increased operating costs caused by the energy crisis is to save funds through minimizing power losses and voltage deviation in the distribution network (Mubarak et al., 2022).

Despite the mentioned negative aspects of the energy crisis, we can find several positive effects in the given event that can help SMEs in their business and improve the overall level of financial health and performance. The need to adapt to excessively increased energy prices will force some SMEs to diversify energy sources so that they are not forced to rely on only one specific energy source. The second possibility is an investment in new energy equipment with renewable energy. A good example of fulfilling the diversification of energy sources while supporting the sustainability, is the installation of photovoltaics. In fact, as one of the main advantages of the energy crisis, we can consider the need for SMEs to look for different ways of reducing electricity consumption and saving financial resources.. By improving the processes associated with the transformation cycle, companies can identify the sources of energy waste and make corrections. Such an action will require a large investment of time and possibly a certain amount of resources to achieve any significant savings for SMEs from which they could benefit in the long term.

Conflict of interest: none.

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Economic Determinants for the Development of Hydropower in the Czech Republic and Poland

Maciej DZIKUĆ[1], Arkadiusz PIWOWAR[2], Milan EDL[3], Maria DZIKUĆ[1]*

[1] University of Zielona Góra, Zielona Góra, Poland; ma.dzikuc@wez.uz.zgora.pl

[2] Wroclaw University of Economics and Business, Poland; arkadiusz.piwowar@ue.wroc.pl

[3] University of West Bohemia, Czech Republic; edl@fst.zcu.cz

* Corresponding author: m.dzikuc@wez.uz.zgora.pl

Abstract: The Czech Republic and Poland face serious challenges related to the further development of renewable energy sources and the continuation of the energy transformation. It should be noticed that the analysed renewable energy source can be particularly easily implemented in rural areas. This is related to the dispersed potential of locating hydropower installations. It should be emphasized that both the Czech Republic and Poland do not fully use the potential of hydropower in rural areas. The aim of the article is to analyse the development of hydropower in the Czech Republic and Poland. The article also demonstrates conditions related to relieving energy transmission networks due to the reduced importance of large coal-fired power plants in Poland and the Czech Republic. Moreover, the article indicates the positive impact of using some hydropower plants as energy storage, which may improve the stability of the energy system locally.

Keywords: renewable energy sources; economy; hydropower; Czech Republic; Poland

JEL Classification: O11; Q28; Q56

1. Introduction

The development of renewable energy in the Czech Republic and Poland is, among other things, an element of improving the quality of the natural environment, a solution supporting the reduction of the use of fossil fuels and a response to the growing pressure from the European Union authorities and European residents to improve the quality of life (European Commission, 2023; Zarębska & Dzikuć, 2013). It should be emphasized that air quality is particularly bad in Poland; according to data from the European Environment Agency prepared by Toute l'Europe, Poland has 7 out of 10 most polluted cities in the EU. The remaining 3 cities are located in Croatia (one city) and Italy (two cities). It should be underlined that Poland is still a country largely dependent on coal. Polish energy industry currently relies on approximately 70% of hard coal and brown coal, which emits huge amounts of suspended dust and other harmful substances when burned. One of the important elements of improving environmental quality is reducing the share of fossil fuels through the development of renewable energy sources, including hydropower (Olczak, 2022; Rokicki et al., 2022). The Czech energy sector is much less reliant on coal due to the two nuclear power plants in operation, which in 2020 accounted for 36.7% of the energy produced (Energetický Regulační Úřad, 2023). The Czech Republic and Poland are not among the leaders in renewable energy in

the EU. The share of RES in both countries is below the EU average (Fig. 1). Additionally, hydropower plays an important role in the energy mix of EU countries. The share of hydropower in the EU-27 was relatively high, accounting for 13.8% of the total net electricity production in 2020 (Eurostat, 2023).
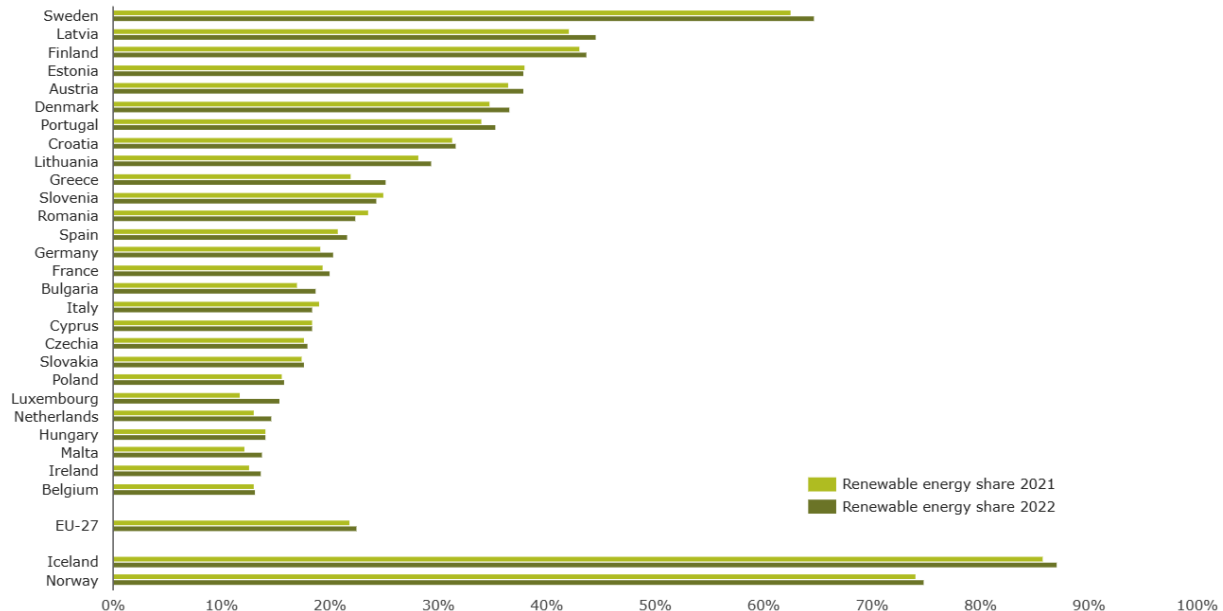
Figure 1. Share of energy from renewable sources, by country (European Environment Agency, 2023)

2. Methodology

The aim of the article is to analyse the development of hydropower in the Czech Republic and Poland. The article also demonstrates conditions related to relieving energy transmission networks due to the reduced importance of large coal-fired power plants in Poland and the Czech Republic (Yan et al., 2021; Raczkowski et al., 2022; Urban & Dzikuć, 2013). Moreover, the article indicates the positive impact of using some hydropower plants as energy storage, which may improve the stability of the energy system locally (Chu et al., 2022).

The methodology of the research conducted in the article is related to the purpose of the analyses. The indicated research goal was a contribution to the use of methods typical of social sciences (Poór et al., 2015). In order to effectively achieve the assumed research objectives, several research methods were used:

- analysis of the subject literature,
- tabular and descriptive charts
- methods of descriptive and mathematical statistics,
- deductive method,
- analysis of source documents.

The collected data was helpful in carrying out analyses of the potential development of hydropower in the Czech Republic and Poland. The analyses performed were used to determine the development potential of hydropower in the coming years. The research used secondary data obtained from central and local government authorities of individual countries. The paper carried out analyses based on statistical data and other information related to the operation and development of hydropower. The research methods and techniques used in the

article allowed achieving the assumed goal. Statistical data and other important information used during the analyses constituted the basis for drawing conclusions regarding the analysed renewable energy source, i.e. hydropower.

3. Results

It should be noted that the development potential of hydropower in the Czech Republic and Poland is limited. However, it is important to analyze the environmental and economic possibilities of developing this renewable energy source. Greater use of the technical potential of hydropower may be an important element in the gradual reduction of the use of conventional fuels. This may be an important element in the development of renewable energy in rural and less urbanized areas (Azarinfar et al., 2024; Heidari et al., 2024).

In Poland, the share of hydropower in total production was much lower than in the EU. However, the share of hydropower production in 2020 in the Czech Republic was higher than in Poland and closer to the EU average, even though in all analysed years the sum of hydropower-based production was lower than in Poland (Table 1). However, due to the much lower total electricity production in the Czech Republic compared to Poland, Czech hydroelectric power plants had a larger share in the total energy production.

The Czech Republic and Poland are located in Central and Eastern Europe with a similar climate. Poland covers an area almost four times larger (312.7 thousand km^2) than the Czech Republic (79.9 thousand km^2) and is also inhabited by many more people (over 38 million) than the Czech Republic (less than 11 million). However, in the Czech Republic the average population density is higher (135.5 people per km^2) than in Poland (122.7 people per km^2). Most of the Czech Republic is located on the Bohemian Plateau and is surrounded by mountain ranges. Poland, on the other hand, is a lowland country with mountain ranges in its southern part. Most of Poland is below 300 m above sea level. The climate of the Czech Republic is mild and depends on the altitude above sea level. In turn, the border between the temperate and subarctic as well as the continental and oceanic climate zones runs through Poland. This causes significant weather variability, especially severe in recent years (e.g. periods of drought).

In the Czech Republic and Poland, most of the rainfall falls in the summer months. However, in winter there is the least rainfall and it occurs mainly in the mountains. The average rainfall in the Czech Republic ranges from 600 mm to 800 mm. However, in Poland the average rainfall is approximately 600 mm with possible significant deviations from the indicated values in both countries. But, similarly to the Czech Republic, Poland also records higher annual rainfall in mountainous areas. The main water divide in Europe is located in the Czech Republic, separating the basins of the Baltic, Black and North Seas. One of the country's main rivers is the Elbe, which flows into the North Sea. The Morava River, in turn, flows into the Danube. The last major river, the Odra, flows into the Baltic Sea. However, approximately 99.7% of Poland's area belongs to the Baltic Sea catchment area, which consists mainly of the Vistula and Odra river basins (nearly 90%) and, to a small extent, the Neman river basin (less than 1%). The rest (just over 9%) constitutes the direct basin of the Baltic Sea.

Table 1. Hydropower electricity production capacities in EU countries - in MW

Specification	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
European Union—27 countries	142,433.708	143,073.780	144,156.131	144,329.264	146,291.976	147,816.738	148,584.348	148,613.314	148,996.193	148,982.176
Belgium	1,426.000	1,427.000	1,429.000	1,431.000	1,422.000	1,419.100	1,417.100	1,417.800	1,414.100	1,415.800
Bulgaria	3,108.000	3,181.000	3,203.000	3,219.000	3,219.000	3,223.000	3,371.550	3,379.000	3,378.350	3,376.456
Czechia	2,023.000	2,029.000	2,064.000	2,062.000	2,069.000	2,071.000	2,080.890	2,080.598	2,080.955	2,081.012
Denmark	9.000	9.000	9.000	9.000	6.878	9.267	7.153	7.153	7.263	7.263
Germany	11,367.000	11,185.000	11,197.000	11,190.000	11,212.000	11,164.000	11,078.000	10,652.000	10,698.000	10,757.000
Estonia	5.000	8.000	8.000	5.000	6.000	6.000	7.300	7.300	6.000	8.000
Ireland	237.000	529.000	529.000	529.000	529.000	529.000	529.000	529.000	529.000	529.000
Greece	3,224.000	3,236.000	3,238.000	3,389.000	3,392.000	3,392.000	3392.000	3,409.000	3,412.000	3,417.000
Spain	18,197.000	18,207.000	18,818.000	18,856.000	19,686.000	19,711.000	19,710.000	19,710.572	19,744.667	19,747.592
France	25,454.181	25,469.754	25,458.073	25,398.027	25,368.096	25,435.177	25,517.417	25,542.147	25,674.256	25,496.113
Croatia	2,127.000	2,127.000	2,176.000	2,178.100	2,192.100	2,189.100	2190.300	2,196.800	2,197.000	2,197.200
Italy	21,568.000	21,752.000	21,890.000	21,979.000	22,099.000	22,181.000	22,307.160	22,393.119	22,434.666	22,604.426
Cyprus	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Latvia	1,571.000	1,573.000	1,585.525	1,586.748	1,586.693	1,563.196	1,563.260	1,563.339	1,585.204	1,584.755
Lithuania	876.000	876.000	876.000	877.000	877.000	877.000	877.000	877.000	877.000	877.000
Luxembourg	1,132.300	1,132.300	1,132.300	1,328.300	1,328.300	1,328.300	1,328.580	1,328.508	1,328.508	1,328.508
Hungary	55.000	56.000	57.000	57.000	57.000	57.000	57.000	57.000	58.000	58.000
Malta	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Netherlands	37.000	37.000	37.000	37.000	37.000	37.000	37.000	37.000	37.000	37.000
Austria	12,642.227	12,773.726	12,848.233	12,997.089	13,112.909	13,570.598	13,717.985	14,088.138	14,162.000	14,169.295
Poland	2,345.000	2,350.000	2,354.000	2,363.000	2,369.000	2,385.000	2,389.559	2,390.768	2,396.512	2,399.102
Portugal	5,529.000	5,706.000	5,655.000	5,709.000	6,162.000	6,954.000	7,219.731	7,229.642	7,255.885	7,234.706
Romania	6,411.000	6,455.000	6,509.000	6,523.000	6,619.000	6,644.000	6,610.437	6,617.714	6,602.737	6,565.675
Slovenia	1,137.000	1,138.000	1,183.000	1,180.000	1,179.000	1,177.000	1,230.926	1,227.716	1,230.090	1,230.273
Slovakia	2,494.000	2,493.000	2,493.000	2,493.000	2,495.000	2,493.000	2,493.000	2,496.000	2,494.000	2,496.000
Finland	2,885.000	2,913.000	2,922.000	2,946.000	2,947.000	2,947.000	2,968.000	2,963.000	2,949.000	2,959.000
Sweden	16,574.000	16,411.000	16,485.000	15,987.000	16,321.000	16,454.000	16,484.000	16,413.000	16,444.000	16,406.000

Source: Eurostat (2023)

Both Poland and the Czech Republic have a rich history of using water energy in economic processes. Originally, it was used in water mills, and the first of them operated in Poland and Czech Republic in the 12th century (Piwowar & Dzikuć, 2022; Havlíček et al., 2022). Its use corresponds to the Pan-European trends (Štěpán & Křivanová, 2000). Its use corresponds to the Pan-European trends. Hydropower systems, including primary ones using the energy of flowing water in the form of a mill, are perceived as basic elements of economic and social development processes, including in rural areas (Szatten et al., 2023). In both Poland and the Czech Republic, and more broadly in Central and Eastern Europe, there have been periods of increased interest and development in hydropower, as well as periods of lack of interest and significant environmental constraints in expanding existing hydropower facilities (Kałuża et al., 2022; Steller et al., 2018).
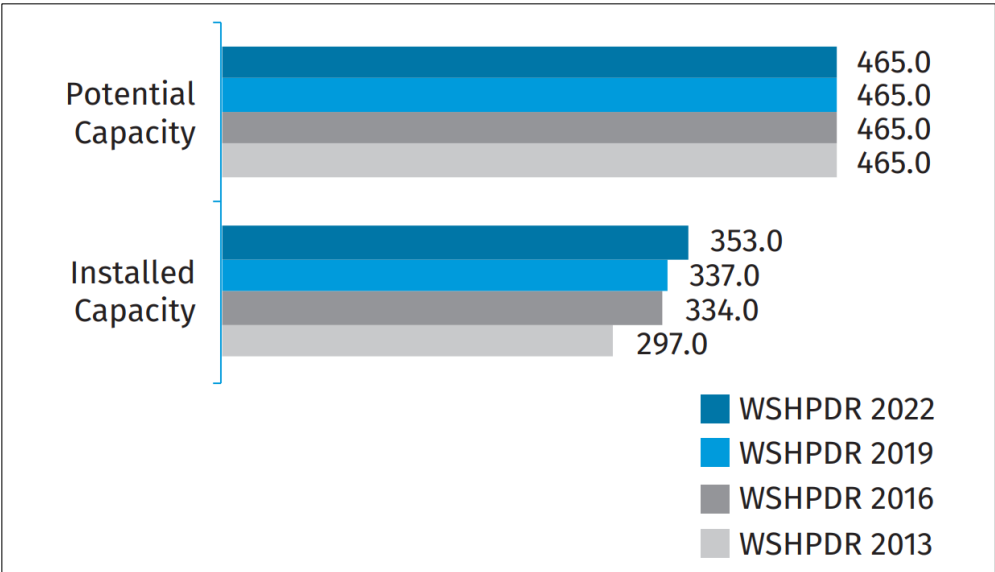
Figure 2. Small hydropower capacities in the WSHPDR 2013/2016/2019/2022 in the Czech Republic (MW) (UNIDO, ICSHP 2022)
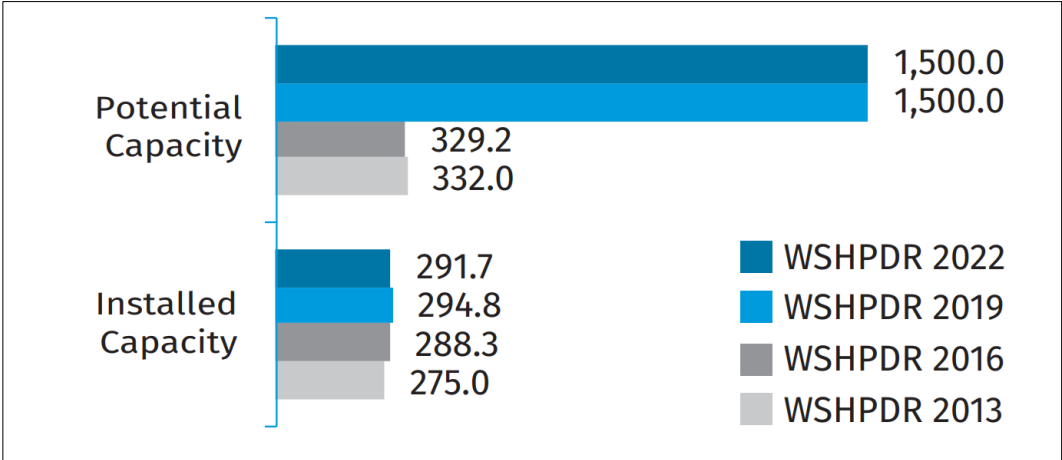
Figure 3. Small hydropower capacities in the WSHPDR 2013/2016/2019/2022 in Poland (MW) (UNIDO, ICSHP 2022)

According to data from World Small Hydropower Development, both the Czech Republic and Poland are currently not using the technical potential of hydropower (Figure 2 and 3). This applies in particular to the possibility of generating energy based on small hydroelectric power plants, which, from the point of view of investment, are less complicated during implementation and have a smaller impact on the natural environment (Dzikuć & Tomaszewski, 2016). This problem is particularly visible in Poland, where about one fifth of the hydropower potential is used (UNIDO, ICSHP 2022).

4. Discussion

It should be emphasized that both the Czech Republic and Poland do not fully use the potential of hydropower in rural areas. The possibilities for dynamic development of hydropower in the Czech Republic are limited because the vast majority of this potential has already been utilized. Nevertheless, the literature indicates, for example, the advantages of natural conditions in the Moravica basin, along the Moravica River, which may be the basis for the creation of new or renovation of old infrastructure for hydropower plants (Havlíček et al., 2022; Duchan et al., 2020; Gono et al., 2012). The situation is completely different in Poland, where there are a large number of potential locations to be developed where hydrotechnical facilities can be built or restored. This is often a relatively easy task because most potential locations for this type of investment remain undeveloped.

An additional benefit may be at least partial use of a hydroelectric power plant as an energy storage facility. This is important because currently in Poland the problem of using energy generated from renewable energy sources, which is periodically produced in excess, has not been solved. This mainly applies to sunny summer days, which are also days off from work. A large number of small hydropower plants could, at least partially, solve this problem. The problem of periodic increases in energy production will intensify in Czech Republic and Poland due to the energy transformation plans, which assume dynamic development of renewable energy sources. Nevertheless, renewable energy sources, at the current state of technology development, do not have the potential to completely replace the power of coal-fired power plants (in Poland) or coal-fired and nuclear power plants (in the Czech Republic) (Charvat et al., 2020). There is currently an ongoing discussion in Poland that nuclear energy should be a large-scale, proven alternative to coal. This is important for the stability of the energy system in Poland and requires many challenges in the technological, logistic and social areas.

5. Conclusions

The analyses carried out in the article demonstrate a significant potential for the development of hydropower, especially in Poland, where the vast majority of locations favourable for this renewable energy remain undeveloped. Although hydropower will not be the dominant renewable energy source in the Czech Republic and Poland in the future, a detailed economic, environmental and technical analysis should be carried out in order to increase the use of the potential of hydropower, which, additionally with certain modifications to the installation, in some cases can also be used as an energy storage facility.

Such actions may, to some extent, reduce the need to expand energy transmission networks and contribute to faster and more effective development of distributed energy.

Conflicts of Interest: none.

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Two-stage Serial Data Envelopment Analysis Models: Comparison of Approaches

Josef JABLONSKÝ

Prague University of Economics and Business, Prague, Czech Republic; jablon@vse.cz

Abstract: Data envelopment analysis (DEA) is a modelling tool for assessment relative efficiency and performance of the set of homogeneous decision making units (DMUs) that transform multiple inputs into multiple outputs. Traditional models consider one-stage transformation – DMUs are black boxes that use multiple outputs and produce multiple inputs. In the contrary, network DEA models assume production process in a more general and complex way. In two-stage serial DEA models, the production process consists of two stages. The inputs of the first stage are used for production of the first stage outputs. These outputs enter the second stage as inputs and are used for production of the final outputs of the production process. The aim of this paper is to compare the most important approaches for evaluation of efficiency of the two-stage serial production processes based on the methodology of DEA. The properties of the models are discussed. A numerical example illustrates the results of all models.

Keywords: data envelopment analysis; network models; ranking; efficiency

JEL Classification: C44

1. Introduction

Traditional DEA models deal with efficiency analysis of one-stage production process, i.e. they analyze the relative efficiency of the transformation of multiple inputs into multiple outputs. The result of this analysis is an efficiency score that express that the unit under evaluation works on efficient frontier (is efficient) or not (is inefficient). This score is computed relatively to the other units of the homogeneous set of DMUs, i.e. adding or removing one unit of the set may (but need not) change the efficiency scores of other units. In general, the production process may be much more complex and cannot be expressed as one-stage process.

Network production processes may consist several interconnected sub-processes. Their efficiency may be analyzed by network DEA models. The simplest case of network structure is a two-stage serial process as presented in Figure 1. Let us consider the DMU_i and denote the inputs of the first stage as x_{ij}, $i = 1,\dots,n$, $j = 1,\dots,m$, and the outputs of this stage that enter the second stage of the process as its inputs as z_{il}, $i = 1,\dots,n$, $l = 1,\dots,p$, where n is the number of DMUs, m is the number of the inputs of the first stage, and p is the number of the outputs of the second stage entering the next stage as inputs. The final outputs (t is their number) of the first stage (not entering the second stage) are y'_{ig} $i = 1,\dots,n$, $g = 1,\dots,t$. Similarly, the independent inputs (their number is s) of the second stage are y''_{ih}, $i = 1,\dots,n$, $h = 1,\dots,s$. The final outputs of the second stage and final outputs of the whole production process are denoted as y_{ik}, $i = 1,\dots,n$, $k = 1,\dots,r$, where r is their total number.

$y''_{ih}, h = 1,\ldots,s$

Stage 1

Stage 2

$x_{ij}, j = 1,\ldots,m$

$z_{il}, l = 1,\ldots,p$
$i = 1,\ldots,n$

$y_{ik}, k = 1,\ldots,r$

$y'_{ig}, g = 1,\ldots,t$
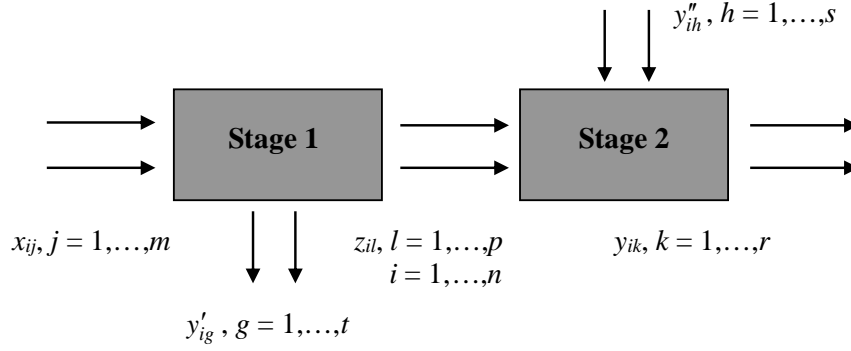
Figure 1: Two-stage serial production process

Network DEA models are of an increasing interest of researchers since the pioneering work (Färe & Grosskopf, 2000) was published. Tone and Tsutsui (2009) extended the current network models by measuring the efficiency using slacks and formulated their slack-based network model. The idea of slack-based measure (SBM) of efficiency was further developed by (Jablonský, 2018). The models for two-stage serial system were introduced in (Kao & Hwang, 2008) and (Chen et al., 2009). These models will be discussed in detail in the next section of the paper. An interesting approach for analysis of network production processes was published in (Mahdiloo et al., 2016). An extensive review of network DEA models can be found in (Kao, 2014).

The aim of this study is to compare the current modelling approaches for efficiency analysis of two-stage serial production processes. Section 2 presents basic definitions and formulations of two-stage serial DEA models. The main shortcoming of these models consists in their results. No DMU of the set need not be identified as efficient, i.e. of units may be inefficient. The model formulated in (Despotis et al., 2023) tries to overcome this shortcoming. This model is introduced in the last part of Section 2. The results of all presented models will be compared in Section 3 using an example of 24 insurance companies. The final section of the paper concludes the research and discusses its results.

2. Methodology

The history of DEA models started by publication of the paper (Charnes et. al., 1978). Their model considers multiple inputs being transformed by the DMU into multiple outputs is often known as CCR model. The input-oriented formulation of this model in its envelopment form can be written as follows:

Minimize $\qquad \theta_q^{CCR}$

subject to $\qquad \displaystyle\sum_{i=1}^{n} x_{ij}\lambda_i + s_j^- = \theta_q x_{qj}, \quad j = 1, \ldots, m,$ (1)

$\qquad \displaystyle\sum_{i=1}^{n} y_{ik}\lambda_i - s_k^+ = y_{qk}, \qquad k = 1, \ldots, r,$

$\qquad \lambda_i \geq 0, \; s_j^- \geq 0, \; s_k^+ \geq 0, \; i = 1,\ldots, n, j = 1,\ldots, m, k = 1,\ldots, r,$

where s_j^-, $j = 1,...,m$, s_k^+, $k = 1,...,r$, are slack variables, and q is the index of the unit under evaluation. λ_i, $i = 1, ..., n$ are non-negative variables of the model that express the intensity of the units of the set in evaluation of the DMU$_q$. θ_q is another variable of the model that express the efficiency score of the DMU$_q$. Its maximum value 1 indicates that the unit q works in an efficient way, values less than 1 indicate inefficiency.

Two-stage serial models are much complicated that the traditional CCR model formulated above. The problem is that the level of efficiency of the unit under evaluation depends not only on the inputs and outputs of one stage. Here, increasing of efficiency of the first stage by increasing its outputs leads to decreasing of the efficiency of the second stage because of its higher inputs. Further in this and following sessions we consider the simplest case of the two-stage serial process where both stages have no independent variables – inputs of the first stage and outputs of the second stage, i.e. $s = t = 0$.

Kao and Hwang (2008) model connects both stages using the middle constraint in the formulation below and considering λ_i and μ_i, $i = 1, ..., n$ intensity variables for the first and second stages respectively. Its input-oriented formulation follows:

Minimize $\quad\quad \theta_q$

subject to

$$\sum_{i=1}^{n} x_{ij}\lambda_i \leq \theta_q x_{qj}, \quad\quad j = 1, 2,...,m, \quad\quad\quad\quad (2)$$

$$\sum_{i=1}^{n} z_{il}\lambda_i - \sum_{i=1}^{n} z_{il}\mu_i \geq 0, \quad l = 1, 2,...,p,$$

$$\sum_{i=1}^{n} y_{ik}\mu_i \geq y_{qk}, \quad\quad\quad k = 1, 2,...,r,$$

$$\lambda_i \geq 0, \mu_i \geq 0, \quad\quad\quad i = 1, 2, ...,n.$$

The efficiency score of the unit under evaluation θ_q is less or equal to 1. The maximum value 1 is reached for the unites that are efficient in both individual stages. Target input and output values can be derived as a linear combination of all other units of the set using optimal values of intensity variables λ_i and μ_i. The output-oriented formulation may be formulated in a similar way.

Chen et al. (2009) formulated two-stage serial DEA model with the assumption of constant returns to scale as follows:

Minimize $\quad\quad \theta_q - \phi_q$

subject to $\quad\quad \sum_{i=1}^{n} x_{ij}\lambda_i \leq \theta_q x_{qj}, \quad\quad j = 1, 2,...,m, \quad\quad\quad (3)$

$$\sum_{i=1}^{n} z_{il}\lambda_i \geq \tilde{z}_{ql}, \qquad l = 1, 2, ..., p,$$

$$\sum_{i=1}^{n} z_{il}\mu_i \leq \tilde{z}_{ql}, \qquad l = 1, 2, ..., p,$$

$$\sum_{i=1}^{n} y_{ik}\mu_i \geq \varphi_q y_{qk}, \qquad k = 1, 2, ..., r,$$

$$\theta_q \leq 1, \varphi_q \geq 1,$$

$$\lambda_i \geq 0, \mu_i \geq 0, \qquad i = 1, 2, ..., n.$$

Similarly to the previous model (2), λ_i and μ_i, $i = 1, ..., n$ are intensity variables for both stages, θ_q and ϕ_q are input-oriented efficiency scores for the first stage and output-oriented scores for the second stage. New variables $\tilde{z}_{ql}$ of model (3) connect both stages of the production process. The DMU$_q$ is efficient in model (3) if it is efficient in both stages, i.e. $\theta_q = 1$ and $\phi_q = 1$. The inefficient units in the first stage have $\theta_q < 1$, the inefficiency in the second stage is indicated by $\phi_q > 1$. The final efficiency score of the DMU$_q$ may be derived as a product of both efficiency scores where ϕ_q must be considered as its reciprocal value. The problem of both models (2) and (3) is the possible inefficiency of all units of the set, i.e. no unit is efficient in both stages, which is a strange conclusion.

Jablonský (2018) combines model (3) and the SBM model introduced by Tone (2001) for the analysis of two-stage processes. This model measures the level of efficiency using slack variables, and its formulation is as follows:

Minimize
$$\psi_q = \frac{1 - \frac{1}{m}\sum_{j=1}^{m}\left(s_j^- / x_{qj}\right)}{1 + \frac{1}{r}\sum_{k=1}^{r}\left(s_k^+ / y_{qk}\right)}$$

subject to
$$\sum_{i=1}^{n} x_{ij}\lambda_i + s_j^- = x_{qj}, \qquad j = 1, ..., m, \qquad (4)$$

$$\sum_{i=1}^{n} z_{il}\lambda_i \geq \tilde{z}_{ql}, \qquad l = 1, ..., p,$$

$$\sum_{i=1}^{n} z_{il}\mu_i \leq \tilde{z}_{ql}, \qquad l = 1, ..., p,$$

$$\sum_{i=1}^{n} y_{ik}\mu_i + s_k^+ = y_{qk}, \qquad k = 1, ..., r,$$

$$(1-\tau)z_{ql} \leq \tilde{z}_{ql} \leq (1+\tau)z_{ql}, \qquad l = 1, ..., p,$$

$$\lambda_i \geq 0, \mu_i \geq 0, \qquad i = 1, ..., n,$$

$$s_k^+ \geq 0, \quad k = 1, ..., r,$$

$$s_j^- \geq 0, \quad j = 1, ..., m,$$

In model (4), $s_j^-, j=1,\dots,m,$ and $s_k^+, k=1,\dots,r,$ are slack variables assigned to the j-th input and k-th output, respectively, τ is a parameter that express a maximum deviations of intermediate target values z_{ql} and new $\tilde{z}_{ql}$ variables. Objective function of model (4) is defined as a ratio of average slacks in the input space and average slacks in the output space – in a similar way as in SBM model (Tone, 2001). Model (4) is not linear in the objective function but can be transformed into a linear model quite easily. The DMUq is efficient in model (4) if all input and output slacks equal to 0, i.e. the objective function of model (4) equals to 1. Lower values indicate lower level of efficiency (or higher level of inefficiency).

A shortcoming of all presented models is a possible inefficiency status of all units, i.e. no DMU is found as efficient which is a strange result. Despotis et al. (2023) developed a simple approach that overcomes this shortcoming. The two-stage production process is considered in two perspectives:

- Perspective 1. The inputs of the first stage are considered to produce both outputs of the first stage and the final outputs of the second stage. In this perspective, the total number of inputs is m, and the number of outputs is ($p + r$). The efficiency score within this perspective can be derived by traditional CCR model (2) or by any other single stage DEA model. Let us denote θ^1 the score derived in this way.
- Perspective 2. The inputs of the first stage are taken together with the inputs of the second stage as the inputs of the new model that produce the final outputs. In this case, the total number of inputs is ($m + p$) and the number of outputs is r. The efficiency score of the new model can be derived by standard CCR model as in the previous case. Let us denote θ^2 the efficiency score in perspective 2.

The overall efficiency score of the two-stage serial system is defined as a geometric average of both scores θ^1 and θ^2. The authors of this approach prove that the application of this procedure leads to the result that at least one unit is overall efficient – (Despotis et al., 2023). If more than one unit is overall efficient, one of the super-efficiency models can be applied to discriminate among them. The inefficient unit can be ranked according to the values of their overall efficiency scores.

3. Results

The results of several modelling approaches for efficiency evaluation of two-stage serial processes will be compared with a data set of 24 insurance companies. The data set is not presented here but can be found in (Kao and Hwang, 2008). This model contains two production stages. The first one considers two inputs (operation expenses of the company and insurance expenses) and two outputs (direct written premiums and reinsurance premiums). Both outputs of the first stage are used as inputs of the second stage. The outputs of the second stage (underwritten profit and investment profit) are the final outputs of the whole system. The first stage evaluates marketing efficiency while the second stage is focused on profit efficiency.

Table 1 presents the results of the evaluation of efficiency of insurance companies using traditional radial one-stage models under the assumption of constant returns to scale – model (1). Table 1 contains the following results:

- The number of the DMU (insurance company).
- CCR 1 – CCR efficiency score of the first stage and ranking of the units according to this indicator. Five units (1, 12, 15, 19, and 24) are identified as efficient in the first stage.
- CCR 2 – CCR efficiency score of the second stage and ranking of the units. Four units (3, 5, 17, and 22) are efficient in the second stage.
- Geom – Geometric mean of the efficiency scores of both stages and ranking of DMUs. The results show that there is no unit efficient in both stages. It is interesting that the best unit according to the geometric mean is inefficient in both stages.
- CCR XY – the results of the CCR model that does not consider intermediate variables – inputs of the first stage are considered for production of final outputs only. Four units (2, 5, 12, and 22) are recognized as efficient in this case. The unit 24 that is efficient in the first stage but extremely inefficient in the second stage has the worse efficiency score among all units.

Table 1. Results of traditional models (constant returns to scale)

DMUs	CCR 1	Rank	CCR 2	Rank	Geom	Rank	CCR XY	Rank
1	0.9926	7	0.7134	7	0.8415	5	0.9840	6
2	0.9985	6	0.6275	10	0.7916	8	1.0000	1
3	0.6900	23	1.0000	1	0.8307	7	0.9884	5
4	0.7243	21	0.4323	16	0.5596	20	0.4882	14
5	0.8375	13	1.0000	1	0.9152	2	1.0000	1
6	0.9637	8	0.4057	18	0.6253	15	0.5938	13
7	0.7521	16	0.5378	13	0.6360	14	0.4698	16
8	0.7256	19	0.5113	15	0.6091	17	0.4148	19
9	1.0000	1	0.2920	23	0.5404	22	0.3270	22
10	0.8615	11	0.6736	9	0.7618	10	0.7807	10
11	0.7405	18	0.3267	22	0.4919	23	0.2826	23
12	1.0000	1	0.7596	6	0.8716	3	1.0000	1
13	0.8107	14	0.5435	12	0.6638	12	0.3527	20
14	0.7246	20	0.5178	14	0.6125	16	0.4696	17
15	1.0000	1	0.7047	8	0.8395	6	0.9793	7
16	0.9072	10	0.3847	19	0.5908	18	0.4717	15
17	0.7233	22	1.0000	1	0.8505	4	0.6349	11
18	0.7935	15	0.3737	20	0.5445	21	0.4271	18
19	1.0000	1	0.4158	17	0.6448	13	0.8220	9
20	0.9332	9	0.9014	5	0.9172	1	0.9351	8
21	0.7505	17	0.2795	24	0.4580	24	0.3328	21
22	0.5895	24	1.0000	1	0.7678	9	1.0000	1
23	0.8501	12	0.5599	11	0.6899	11	0.5990	12
24	1.0000	1	0.3351	21	0.5789	19	0.2571	24

Table 2 contains similar results as Table 1 but for the two-stage methods including the newest approach (Despotis et al., 2023). Table 2 has the same structure as the previous table.

There are presented efficiency scores derived by the methods and the ranking of DMUs according to these scores. The following methods are included:

- Kao – Kao and Hwang (2008) method – model (2). One can notice that no unit is efficient according to this approach, and all efficiency scores (except the DMU$_9$) are very low.
- Chen – The efficiency scores given by Che et al. (2009) method – model (3) – are higher that those from the previous case but again, no unit is efficient. The rankings of units obtained by both methods are the same.
- SBM – SBM model (4) is based on different principles than the remaining radial models. This is the reason that the ranking of units is here little different to the rankings of other methods.
- Despotis – The results of Despotis et al. (2023) model are presented in the last two columns of Table 2. They show the main property of this model that at lleast one unit is efficient – in our case three units (9, 10, and 12) are efficient.

Table 2. Results of two-stage models (constant returns to scale)

DMUs	Kao	Rank	Chen	Rank	SBM	Rank	Despotis	Rank
1	0.3936	4	0.6274	4	0.3578	2	0.9653	5
2	0.1472	21	0.3836	21	0.1777	17	0.4743	22
3	0.1738	17	0.4169	17	0.2010	15	0.5521	19
4	0.1714	18	0.4140	18	0.1268	20	0.7898	11
5	0.1317	22	0.3629	22	0.2901	9	0.5307	20
6	0.3530	7	0.5942	7	0.2550	11	0.8841	8
7	0.2200	14	0.4691	14	0.1736	18	0.6177	17
8	0.1640	20	0.4049	20	0.3045	7	0.6276	16
9	0.9338	1	0.9663	1	0.3378	3	1.0000	1
10	0.3962	3	0.6294	3	0.3338	4	1.0000	1
11	0.1644	19	0.4055	19	0.1842	16	0.5195	21
12	0.4774	2	0.6909	2	0.3259	5	1.0000	1
13	0.2779	10	0.5271	10	0.2972	8	0.7734	12
14	0.3059	9	0.5531	9	0.3064	6	0.8647	9
15	0.3498	8	0.5915	8	0.2200	13	0.9199	7
16	0.2760	12	0.5254	12	0.0793	22	0.8254	10
17	0.3745	6	0.6119	6	0.1116	21	0.9632	6
18	0.2778	11	0.5271	11	0.2615	10	0.7638	14
19	0.3748	5	0.6122	5	0.1498	19	0.9935	4
20	0.2598	13	0.5097	13	0.5430	1	0.7683	13
21	0.1998	15	0.4470	15	0.2066	14	0.6471	15
22	0.1995	16	0.4466	16	0.2321	12	0.6020	18
23	0.3936	4	0.6274	4	0.3578	2	0.9653	5
24	0.1472	21	0.3836	21	0.1777	17	0.4743	22

Correlation coefficients between all pairs of efficiency scores computed by the presented approaches are presented in Table 3. They show that the level of correlation between traditional efficiency measures computed by CCR model in the first and second stages are very low and the correlation is rather negative. This conclusion is not surprising as the outputs of the first stage lead to the lower efficiency of the second stage. The same holds for comparison of the measures derived by all other models – the level of correlation between

efficiency scores of the first stage and all other measures is very low. The results of Despotis et a. (2023) model are strongly correlated with other two-stage models, and also with results of the model that does not take into account the intermediate variables (CCR XY). There is almost perfect positive correlation between Kao and Hwang (2008) and Chen et al. (2009) models.

Table 3. Correlation between the efficiency scores

	CCR 1	CCR 2	CCRXY	Geom	Despotis	Kao	Chen	SBM
CCR 1	1.0000							
CCR 2	-0.2274	1.0000						
CCR XY	0.2058	0.7828	1.0000					
Geom	0.1889	0.9026	0.8788	1.0000				
Despotis	0.2236	0.8428	0.9523	0.9375	1.0000			
Kao	0.2153	0.7691	0.9657	0.8735	0.9081	1.0000		
Chen	0.2002	0.7721	0.9737	0.8736	0.9148	0.9944	1.0000	
SBM	0.0278	0.7275	0.5993	0.7122	0.6669	0.5725	0.5757	1.0000

4. Discussion and Conclusions

DEA models for efficiency and performance evaluation of two-stage serial production processes are the simplest models of the broader family of network DEA models. The general production system can be considered as a combination of serial and parallel sub-processes. To evaluate the efficiency of such complex processes, various DEA based models have been formulated in the past. A general SBM model was formulated in (Tone & Tsutsui, 2009). A review of DEA network models was published in (Kao, 2014). This study formulated a set of the most often used two-stage serial DEA models and compared their results on a case of 24 insurance companies. The results show that the final efficiency score of the whole system depends mainly of the efficiency of the second stage. The results of all two-stage models considered in the study are more or less consistent with each other. Future research in this field will be focused on considering a dynamic factor to the analysis, i.e. formulation of dynamic DEA models because time factor is not solved satisfactorily yet.

Conflict of interest: none.

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Sustainability in Transportation through the Eyes of Czech Consumers

Eva JADERNÁ* and Lukáš GERHARDT

Skoda Auto University, Mladá Boleslav, Czech Republic; eva.jaderna@savs.cz; ext.lukas.gerhardt@savs.cz

* Corresponding author: eva.jaderna@savs.cz

Abstract: Sustainable transport is a highly debated topic in the context of reducing the carbon footprint. Among other things, this article provides an overview of different perspectives on sustainable transport behavior. The researchers focused on the Czech consumer and some aspects of their sustainable transport behavior. The aim of this paper is to present the results of a questionnaire survey on a representative sample of Czech consumers. The investigation focused mainly on the frequency of car use for transport, popularity and options for carsharing or public transport. Among others, factors hindering the use of public transport were identified. Furthermore, the researchers' attention was focused on the perceived environmental friendliness of different modes of transport. The results show that the Czech consumer perceives eco-friendly modes of transport positively, but he himself does not behave very sustainably in personal transport for various reasons, which will be presented in this article.

1. Introduction

The chapter is focused on defining the concept of sustainability, specifically examining how sustainability is understood in the context of transportation. Various forms of sustainable transportation are described. Subsequently, current trends in the Czech Republic's automotive market are introduced in the context of the shift towards sustainable behavior in transportation. This chapter enlighten aspects of sustainable transportation examined in a research study, the results of which are later discussed in Chapter 2.

In this context, sustainability is conceptualized as a form of development that satisfies current needs without compromising the ability of future generations to meet their own needs. Emphasis is placed on consideration for future generations and a review of the impacts of consumer behavior. An alternative interpretation underscores the elemental idea that a sustainable system is one that survives and persists (Costanza & Pattern, 1995). This concept is further developed through the pillars of the Triple Bottom Line.

Sustainability is fulfilled on multiple levels, as outlined in the Triple Bottom Line, defined by John Elkington in the 1990s (Elkington, 2018). The Triple Bottom Line defines the main three pillars of sustainability – people, planet, profit. These represent the economic, environmental, and social pillars, which should be fulfilled synergistically. When addressing environmental protection in the context of transportation, it is necessary to also consider the

economic and social aspects of decision-making. Moreover, not all measures leading to sustainable transportation may be embraced by consumers and may not align with their needs and capacities (both social and economic pillars).

In the context of transportation, the phenomenon of sustainable development is closely associated with environmental impact, primarily addressing the reduction of CO_2 emissions. Transportation, especially personal road transportation, significantly contributes to environmental pollution through CO_2 emissions. Specifically, it is responsible for 60% of all emissions from transportation. Additionally, within the European Union, transportation accounts for almost 24% of all total emissions produced. Therefore, sustainability in transportation is primarily discussed in the context of reduction of CO_2 emissions (faktaoklimatu.cz).

Within the context of sustainable transportation, reducing CO_2 emissions is a fundamental aspect of achieving a less pollution produced in transportation. Sustainable transportation is based on operating and managing transportation with minimal negative impacts. It is, therefore, crucial to be aware of the impacts of one's behavior. Unfortunately, CO_2 emissions in transportation are continually increasing. From 1990 to 2015, they nearly doubled (Zatloukal, 2015). However, in recent years, 2016, 2017, and 2018, the upward trend stopped due to the use of better fuels with different compositions and more efficient utilization of combustion engines, along with the gradual introduction of electric vehicles (ČHMÚ, 2020). The pandemic crisis halved emissions in land transportation compared to 2019; nevertheless, a return to higher numbers is expected. Restricting transportation could be one solution to the climate crisis, however this does not align with consumer needs.

Personal road transport significantly contributes to the deterioration of the situation carbon neutrality situation; therefore, attention is primarily focused on eliminating its impacts. On the other hand, statistics from the Association of Automobile Importers indicate an increase in registrations of new cars in the Czech Republic. Registrations peaked in 2017, followed by a decline. However, compared to 2004, when 125,768 new cars were registered, the 192,087 new cars registered in 2022 are still more than half higher.
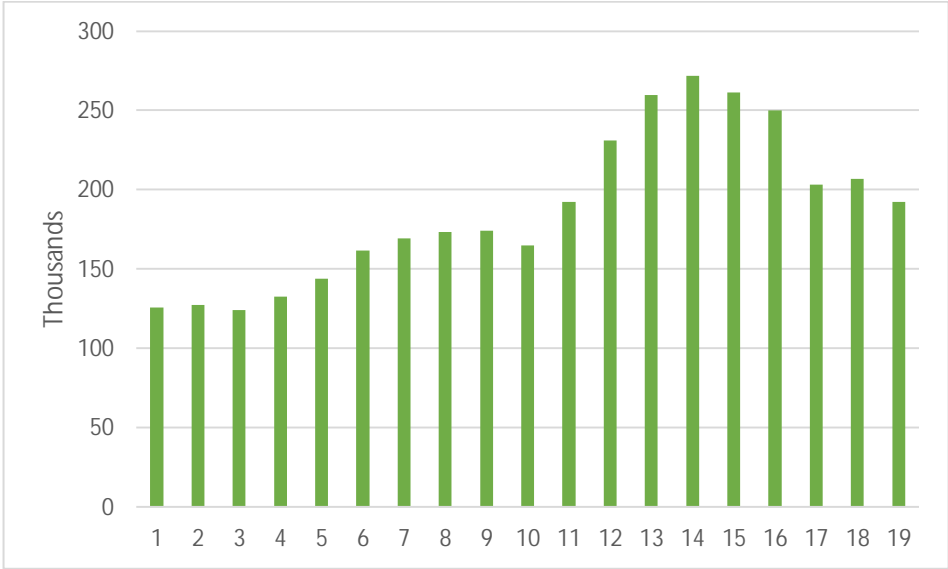
Figure 1. New car registration in the Czech Republic (based on the data according to the Association of automobile importers (2022a))

The decline of total number of newly registered cars in the last five years cannot be labelled as a shifting towards sustainable transportation in the Czech Republic. The COVID crisis followed by decreasing demand played a significant role in lower number of registrations. Thanks to the COVID crisis we are facing an increasing age of the vehicles used in a personal transportation. Older vehicles, in the context of emissions during vehicle operation, may be perceived as less sustainable than newly registered cars with lower emissions production during their lifetime.

The age of the vehicle fleet in the Czech Republic has shown a consistently increasing trend. In 2011, it was 15.36, and in 2022, the age of the vehicle fleet was 18.94. The latest data for the first two quarters of this year is already above the 19-year threshold, specifically 19.06 (Association of Automobile Importers, 2023b).
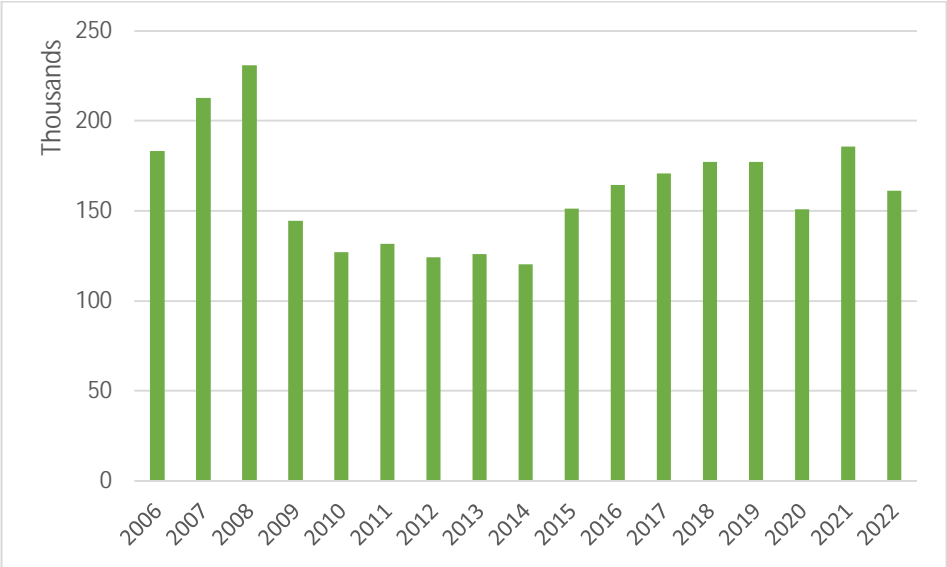
Figure 2. Used cars sales in Czech Republic. Source: processed data according to the Association of automobile importers (2022c)

The trend of buying used cars was more significant before the year 2010, as illustrated in Figure 2. However, even in recent years, the number of sold used cars has not fallen below the threshold of 150,000. This trend cannot be solely attributed to a sustainable transportation trend. Achieving sustainable transportation is possible based on four synergistic pillars: attractive public transportation, pedestrian accessibility, compact urban planning, and restrictions on car usage (Eliasson & Proost, 2014). Nevertheless, consumers themselves can significantly contribute by changing their mindset and preferences towards greener future.

Forms of sustainable transport

Czech regional and district agglomerations have long been grappling with traffic chaos, jams and congestion in general. The usual response is the construction of new roads, expansion of existing ones, and the building of bypasses. However, these measures often encroach upon arable land or green areas, posing threats to the health and safety of residents. Moreover, this trend encourages the growth of personal road traffic and an interest in private vehicles.

A sustainable solution, on the other hand, could involve promoting public, pedestrian, or cycling transportation (Stránský, 2022). The primary issue lies in the increasing number of cars. According to Healey (2022), various shared transportation options, such as shared cars, public transportation, shared bikes, or taxi services, could help reduce the number of owned vehicles. In his study, he also suggests another emissions reduction possibility—eliminating transportation altogether by embracing remote work.

The Czech ministry of transport is addressing the issue of traffic overload and chaos. It has responded to the European methodology SUMP (Wefering et al., 2014), which focuses on these strategic areas:

- Ensure that all residents have access to transportation options that allow them to reach key destinations and services.
- Enhance transportation safety.
- Reduce pollution, noise, greenhouse gas emissions, and energy consumption.
- Improve the efficiency of both passenger and freight transportation.
- Contribute to enhancing the attractiveness and quality of the urban environment for residents, the economy, and society.

The methodology of the ministry of transport of the Czech Republic, based on these strategic areas, has defined its visions and possibilities for their fulfilment, as shown in the following Table 1.

Table 1. Mobility vision

Mobility vision	Strategic goal	Specific goal	Measures and suitable activities (selection)
City with a high-quality living environment	Reduce the number of residents exposed to excessive noise by 20% within 10 years	Decrease noise load below the limit value on specific urban routes	Reduce driving speed; modernize public transport vehicles and infrastructure
City with safe transportation	Decrease the number of traffic accidents with serious injuries or fatalities by 50% withing 10 years (EU target)	Reduce the number of accidents involving pedestrians at crossings and locations for crossing and cyclists at cyclist crossings by 50%	Add and improve pedestrian crossings and cyclist crossings; ensure visibility at crossing locations; a campaign focused on illuminating cyclists
City with quality public transport	Transport Increase the share of public transport journeys by 3% within 10 years	Increase the number of public transport passengers on a specific route between the city center and residential area by 15%	Dedicated lane for public transport vehicles; preference for public transport vehicles at intersections; optimization of the timetable

Public transport, pedestrian, and cycling mobility are significantly supported in the context of the social aspects of sustainability. Safety, noise, or a high-quality living environment is a priority. Moreover, transportation significantly influences the economic

aspect – fuel prices, public transport fares, opportunities to purchase electric vehicles, or shared transportation.

The World Commission on Environment and Development (1987) defines sustainability as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It is necessary to ensure that the mobility of current generations does not excessively impact the mobility options of future generations.

2. Methodology

Sustainability in transportation has been the subject of interest for researchers addressing the project of the Student Grant Competition at the Škoda Auto University. Czech consumers and their attitudes or perceptions of sustainable transportation are crucial to describing consumer behavior. From a marketing perspective, it is an opportunity to effectively communicate sustainable principles in transportation by knowing their habits and believes. First, desk research was conducted to uncover important aspects of sustainable behavior in transportation via using data and published results from previous research surveys at the Škoda Auto University. The current factors of sustainable behavior in transportation were identified through the comparison of these results and the analysis of secondary data.

By defining the research gaps and identifying the basic attributes of sustainable transport behavior, the following research question was formulated: 'What is the sustainable transport behavior of Czech consumers in the context of using private cars, carsharing or public transport?' Answering this question can help to better understand the consumer, their attitudes, perceptions and needs. Also for this reason, attention is paid to differences between different age groups in their perception of sub-aspects of sustainable transport behavior, e.g. carsharing or preference for electric vehicles.

Subsequently, a questionnaire survey was organized in collaboration with the research agency BehavioLabs in February 2023. The research aimed to describe the sustainable behavior of Czech consumers in transportation based on established factors of sustainable behavior in transportation. First, based on the stated research objective, the operationalization was carried out in the context of the assigned topic of sustainability in transport. The key aspects were broken down into sub-topics so that the questionnaire met the requirements of clarity, readability and functionality, or relevance to the topic of the survey. The cooperating research agency has many years of experience in creating and distributing questionnaires and was a significant help in this phase to achieve relevant data and a representative sample of Czech respondents. A total of 1,000 completed questionnaires were used in data processing, with a quota selection of respondents based on the research agency's respondent panel ensuring the representativeness of the respondent sample, and the data from the questionnaire survey can be generalized.

The interpretation of the results in this chapter will focus on describing the use of cars by Czech consumers, its frequency, reasons for not using cars, and motives for driving. Attention will also be focused on car-sharing and the use of public transport. From the perspective of Czech consumer attitudes, the results of a survey section dedicated to the perception of different types of transport from an environmental perspective will be

presented. To complement the frequency analysis, contingency tables were developed to demonstrate the relationships between the age of respondents and the sub-aspects of sustainable transport behavior.

3. Results

3.1. Czech Consumers and their Car Usage

Transportation for most Czechs means using cars for their own mobility. Therefore, it was necessary to find out how much car transport is used by Czech consumers and potentially confirm this trend. From the graph in Figure 3, it is evident that a significant portion of the Czech population uses a car practically every day (48% of respondents). At least once a week, 261 out of 1000 respondents drive a car. Similarly, 13% of respondents stated that they drive a car once a month, less frequently, or not at all.
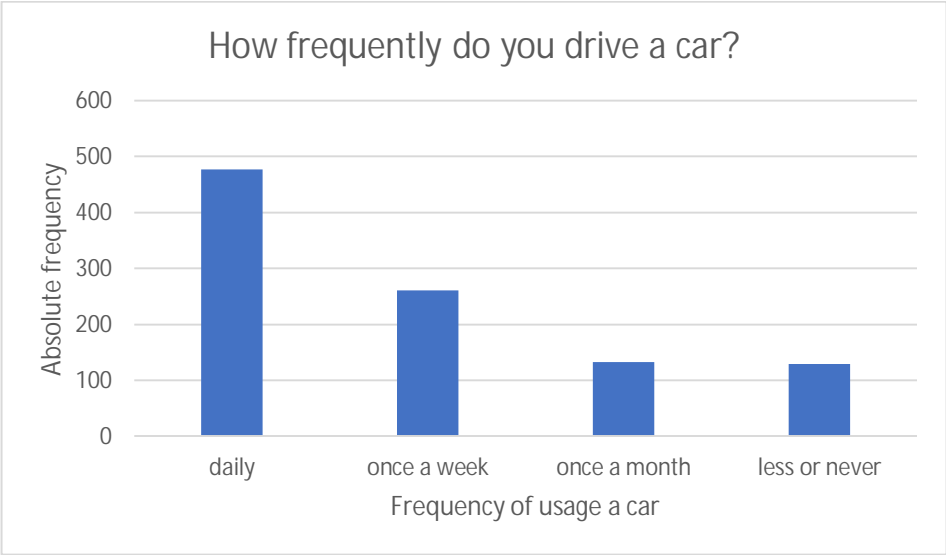
Figure 3. Frequency of car use

The next question was focused on the reasons leading respondents to limit car usage. The question was answered only by respondents who drive less frequently or once a month. The following graph in Figure 4 does not indicate that the ecological aspect plays a significant role in the decision to use a car. Only 48 out of 262 respondents answered that they want to save the environment. The financial aspect is addressed by 77 out of 262 respondents.

The use of car traveling was also examined from the perspective of why consumers use the car for. Respondents could choose multiple answers from the options provided. Three quarters (74%) answered shopping. For weekend trips to visit family, cottages, or excursions, 59% of respondents use a car. Similar percentages are reported for commuting to work and vacation travel (47% for work, 49% for vacation), which also corresponds to the responses regarding the frequency of car travel. Nearly 50% of respondents use a car every day, suggesting that transportation to work is a significant factor. 36% of respondents pick up children or family members by car, and only 22% use a car for work-related reasons (drivers, sales representatives, etc.)

Figure 4. Reasons for limited usage of car
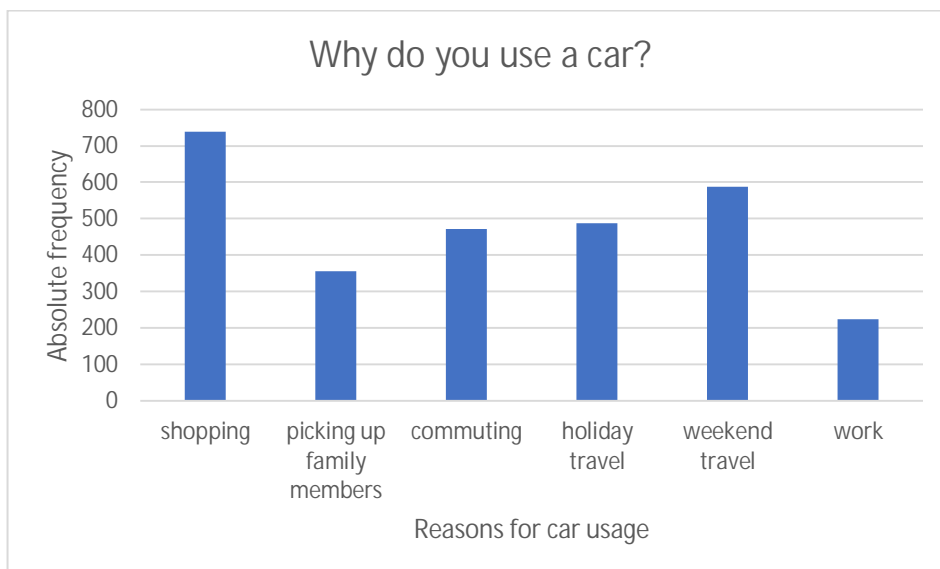
Figure 5. Reasons for car usage

From the above, it is evident that Czechs use cars frequently, mainly for their shopping or weekend trips. The reasons for their use outweigh the costs, and environmental considerations deter other, additional reasons.

3.2. Czech Consumers and Sustainable Transport

Sustainability in transportation is a trend addressed not only internationally but has been a subject of discussions on various levels in the Czech Republic for several years. The need for change is becoming increasingly prominent. Consideration is given not only to the elimination of car transportation but also to electromobility. These two directions were assessed in another questionnaire question. Consumer opinions on electromobility and other forms of transportation, in the context of their ecological impact, are crucial aspects for subsequent communication about electric vehicles.

As indicated by the graph in Figure 6, the train ranked as the most sustainable type of transport in the evaluation by Czech consumers. The ranking system is set from 0 to 5 (0 for the most sustainable type of transport, 5 for the least sustainable type of transport). Train was ranked on a first place by 408 respondents. In contrast, the least favorable rating, with an average of 4.725, was given to gasoline/diesel cars, followed by buses with an average ranking of 4.043. The electric car is perceived as highly ecological, ranked first by 304 respondents, with an overall average ranking of 2.991. In the Czech Republic, the number of newly registered electric vehicles is around 2%, and the first two quarters of 2023 indicate an increase to 3.15% of the total number of newly registered cars. While the percentage is growing, from the perspective of the European Union's direction, the goal is still quite distant. Significant sustainability factors, such as the purchase price of the vehicle or the inexperience of Czech consumers with electric cars, play a substantial role here. (Jaderná et al., 2018).
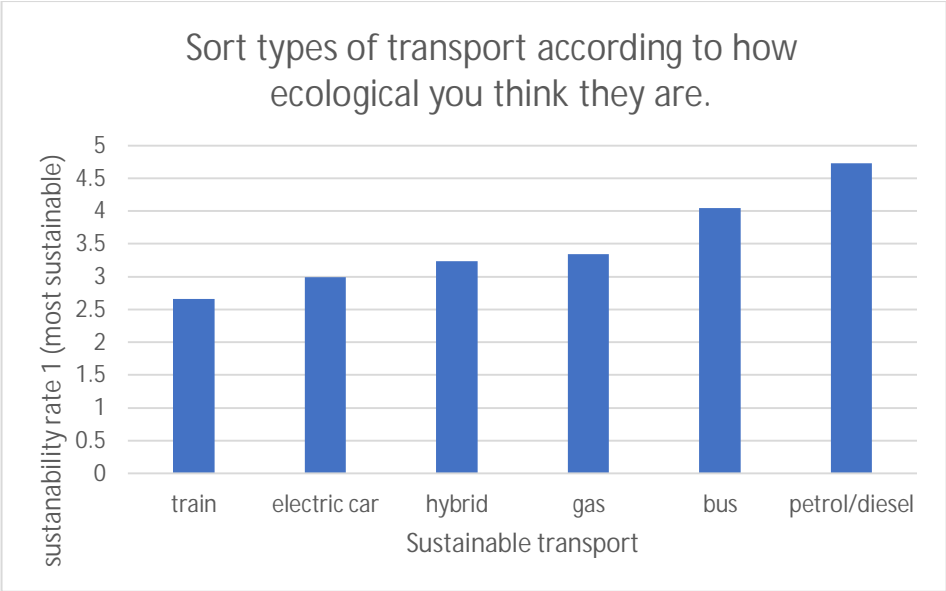
Figure 6. Types of transport sorted from the most sustainable to the least sustainable

The previous graph shows that electric cars are perceived as very environmentally friendly. But what is the interest in buying an electric car? The contingency table presented below compares the willingness to buy an electric car between different age categories. For clearer results, the answers have been converted into a relevant frequency, i.e. a percentage of the total number of respondents in the given age categories.

This shows that the two oldest age categories are the least interested. 19% of respondents aged 55-64 and 12% of respondents aged 65+ gave the answer maybe. Conversely, 43% of respondents aged 18-24 are considering buying an EV and absolutely not 50% of respondents aged 18-24 are considering it, compared to 78% of those aged 55-64 and 83% of those aged 65+.

Table 2. Buying of an electric car

Age Group	18–24	25–34	35–44	45–54	55–64	65+
Definitely	6%	6%	3%	5%	2%	2%
Maybe	43%	32%	32%	25%	19%	12%
Has	1%	0%	1%	1%	1%	3%
No	50%	62%	64%	69%	78%	83%

Shared mobility is one of a sustainable form of transportation. Carsharing is a car rental for a short period of time through a mobile application. The application locates an available vehicle at a specific address, and it can be reserved online. In the Czech Republic, there are already 1,890 cars operating in this mode (DopravaDnes.cz, 2023). However, the graph in the following image indicates a lack of interest from the Czech consumers in carsharing sphere. Out of 1,000 respondents, 768 do not use carsharing and have no interest, 171 of respondents express interest but have not used it yet. Only 13 people use carsharing frequently, and 48 use it occasionally. The question remains whether the reason is lack of interest or unfamiliarity with this alternative.
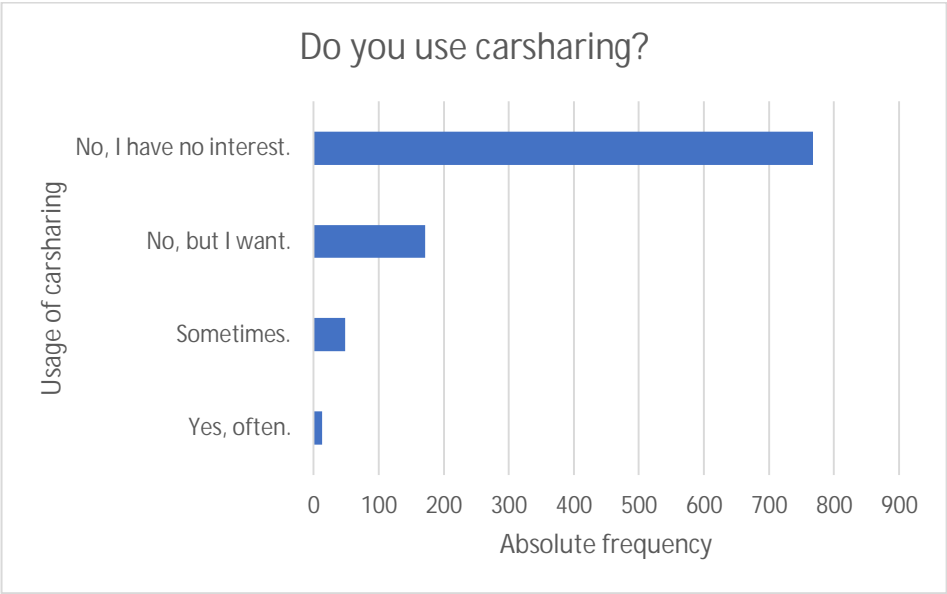
Figure 7. Carsharing usage

Again, the focus was on differences between generations. The contingency table shows that younger people are the most interested in using carsharing. 26% would like to use carsharing and 62% are not interested, but this is still the lowest number compared to other age groups.

Table 3. Usage of carsharing

Age Group	18–24	25–34	35–44	45–54	55–64	65+
Yes, often	4%	2%	2%	0%	1%	0%
Sometimes	8%	7%	6%	4%	2%	2%
No, but I want	26%	19%	19%	19%	8%	10%
No, I have no interest	62%	72%	73%	76%	89%	88%

The European Union, as part of its "Fit for 55" plan, extends the concept of climate neutrality to 2050. In this case, it is necessary to reduce greenhouse gas emissions in the transportation sector by 90% while ensuring accessible solutions for citizens (European Council, 2022). Addressing the carbon crisis requires a transformation not only of the industry itself but, more importantly, a change in attitudes, habits and behavior towards sustainable transportation. The following graph in Figure 8 illustrates the use of alternative modes of transportation other than cars in the Czech Republic.

782 respondents prefer walking instead of driving. 537 out of 1,000 respondents choose the bus, while 40% prefer trains. Tram, metro, or trolleybus is favored by 37%, and 31% opt for bicycles or scooters. Only 65 out of 1,000 respondents use a motorcycle or scooter. It is worth noting that people from various-sized cities answered the question. Nevertheless, the preference for walking is overwhelming.
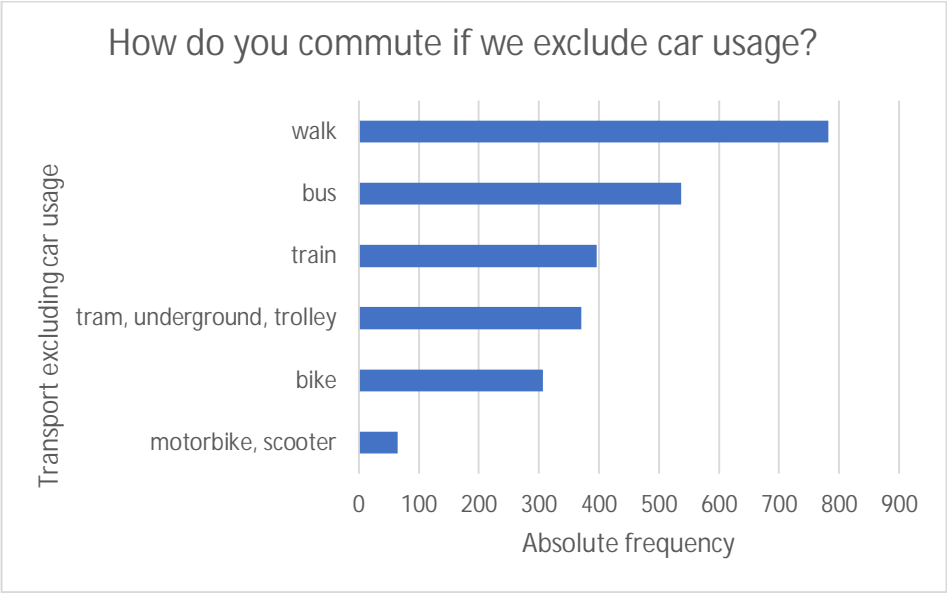
Figure 8. Alternative transport usage

Respondents were also asked whether they ever use public transportation, not only urban public transportation. All respondents answered this question, and the results indicate that more than 40% of Czechs do not use public transportation at all or less than once a month. This response corresponds to the figure of 48% of respondents who drive a car every day. 245 out of 1,000 respondents use public transportation essentially every day, and the same percentage of respondents, 17%, stated that they use public transportation at least once a week or once a month.
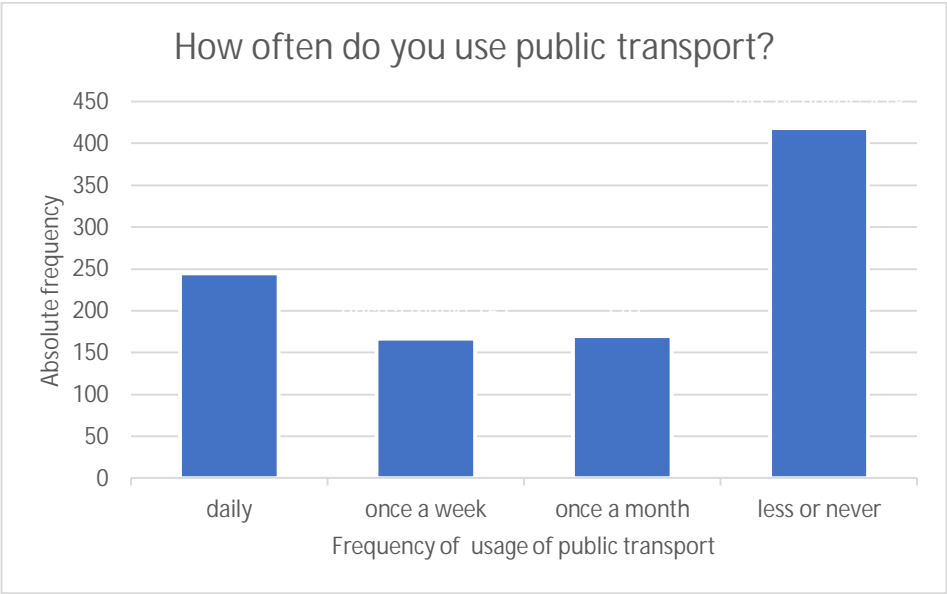
Figure 9. Usage of public transportation

The reason why Czechs use public transportation less frequently is primarily because the connections do not suit them or are infrequent, as indicated by 37% of all respondents. Another significant reason is that it is often overcrowded (stated by 32% of respondents). The time aspect is a problem for 29% of respondents in the case of public transportation. Other reasons fall below the 20% threshold and include discomfort, lack of hygiene, or the bus or tram stop being too far away. Additionally, 10% of respondents mentioned that it is too expensive for them.
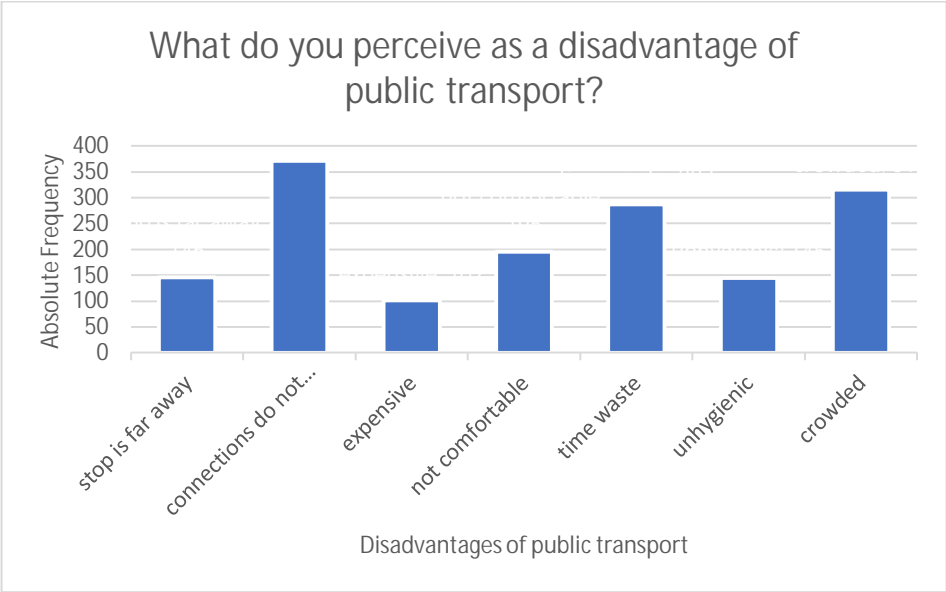
Figure 10. Struggles with public transport

Environmental aspects of sustainable transport should be supported regarding the social and economic dimensions of consumer decisions. The Triple Bottom Line, with its pillars, as well as other definitions of sustainability, look not only at environmental protection. If using public transportation is not realistic due to poor connections or its time constrains, it is necessary to focus attention not only on the environmental sustainability of the consumer but especially on improving other transportation alternatives. Above all, it is essential to ensure affordable transportation that meets frequency requirements, accessibility and financial availability.

4. Discussion

Sustainability is perceived diversely by Czech consumers concerning various needs and the products they purchase. When it comes to lower-priced products or everyday consumer goods, the situation differs from the purchase of higher-priced automobiles. Sustainable principles are more frequently followed in everyday consumption; however, sustainable personal road transport, such as electric cars, remains a significant challenge for them. On the other hand, in the context of sustainable transportation, there is talk of using car-sharing, public transport, or completely restricting to walking or cycling. These alternatives differ in terms of purchase price from buying a car, but long-term support from the state (primarily infrastructure development) is necessary.

Knowledge of the customer and their consumption behavior is crucial for marketing communication decisions. Similarly, knowing consumer preferences in transport is important for strategic planning at the regional or national level. In the context of understanding consumer behavior in the transport sector, research gaps have been identified with regard to the results of a longitudinal study at Skoda Auto University in the context of the student grants.

Significant attributes of sustainable transport include a lower frequency of car use, on the contrary the use of carsharing, public transport and an inclination towards electromobility. All these aspects were examined in the context of the research question: "'What is the sustainable transport behavior of Czech consumers in the context of using private cars, carsharing or public transport?'

Czech consumers do not behave very responsibly in terms of sustainability in transport. More than 78% of respondents drive a car every day, mainly to do their shopping or go on trips. According to the perception of the Czech consumer, the most environmentally friendly mode of transport is the train, followed by electric cars. However, interest in buying an EV is low. The researchers were interested in the younger generation, which often tends to be more inclined towards sustainable principles. In this context, a higher inclination to buy an EV was confirmed, but also a greater interest in carsharing. The latter is uninteresting for older generations.

This raises the question to what extent the younger generation can reverse the current trends in sustainable transport behaviour of Czech consumers. It is clear that marketing communication of EVs in terms of green transport is effective. Other communicated aspects of sustainability, such as carsharing, public transport, are equally effective, especially for the young generation. Marketing support can therefore be a solution. However, a major barrier to the use of carsharing or public transport is its availability. The most important factor for public transport is considered to be that the services are not connecting or are overcrowded.

This is more than a challenge for marketers, it is a challenge for county and state representatives in transportation infrastructure planning.

5. Conclusions

Sustainable transportation is a challenge not only for legislators, businesses, and philanthropists but significantly impacts daily life of consumers. Embracing new sustainable trends must go hand in hand with fulfilling common needs. It is, therefore, necessary to consider the social and economic impact of decisions to adhere sustainable principles. A significant portion of Czech consumers still predominantly relies on automotive transportation, with 48% daily usage. Most people use cars for shopping and weekend getaways. The reduction in car usage is not supported by statistics on the registration of new and used cars. On the contrary, the age of vehicles is increasing, exceeding emission limits more frequently.

Sustainability in transportation can be achieved through various forms. One of them is using the most ecological mode of transportation possible. According to Czechs, the most environmentally friendly option is the train, followed by electric cars. Czech consumers consider a car with an internal combustion engine and bus transportation the least ecological. Carsharing is currently unattractive for Czechs; only a negligible percentage uses it, although there are already 1890 cars available through this service in the Czech Republic. However,

there is hope for growing interest in this service, especially among the younger generation of Czech consumers (Bělohlávková, 2021). In addition to cars, Czechs are making efforts to walk as much as possible or use buses and trains. Almost 25% of respondents use public transportation daily, while on the other hand, more than 40% do not use public transportation at all or less than once a month. The main reasons are the lack of connections between routes or overcrowding. Additionally, the time factor is crucial, as public transportation is usually more time-consuming.

In the long term, it will be desirable to draw attention to alternative forms of transportation, such as carsharing. Importantly, it is crucial to ensure sufficient capacities of public transportation that are both affordable and time friendly. Another milestone is promoting walking through the construction of new paths, crossings, and overpasses, rather than focusing on building more roads and bypasses. Furthermore, automakers will compete for every customer purchasing an electric vehicle in the Czech market. Due to product unfamiliarity and excessively high acquisition costs, electric cars are still unattractive. These are the challenges that supporters of sustainable transportation will face.

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Factors and Barriers to Change Implementation in Micro, Small, and Medium-Sized Enterprises

Lukáš KLARNER*, Petr ŘEHOŘ, Jaroslav VRCHOTA and Monika MAŘÍKOVÁ

University of South Bohemia in České Budějovice, České Budějovice, Czech Republic; klarnl00@ef.jcu.cz; rehor@ef.jcu.cz; vrchota@ef.jcu.cz; marikova@ef.jcu.cz

* Corresponding author: klarnl00@ef.jcu.cz

Abstract: The current dynamic times force companies to observe their surroundings and accept changes constantly. Several circumstances and barriers affect the successful implementation of changes. In addition to eliminating these barriers and positively influencing other related factors, businesses need to address several other change-related issues. This paper discusses change management and the factors preventing successful implementation of change. The main aim is to evaluate the interdependence between the selected barriers, defined based on a questionnaire survey. The survey involved 141 micro, small, and medium-sized enterprises in the Czech Republic. Five main barriers and problems businesses face in implementing the change have been identified. These include "poor communication, ineffective strategic management and planning, financial constraints, dysfunctional teamwork, and inadequate leadership." The secondary objective of the paper is to identify other related areas and concepts associated with change management barriers at a general level. The PRISMA 2020 process and the VOSviewer program were used for this analysis. It was found that the most frequently discussed issues in connection with the implementation of changes are the organization's performance, the impact of the change, its management, and knowledge related to the change.

1. Introduction

The dynamic environment of the present time affects all areas of organizational management. All levels and functions of management are concerned. A critical site for successful change implementation is strategic management. Without an adequate strategy or plan for change in general, it is possible that it will not be able to enforce the change, or the company will not be able to identify when it has been successfully adopted (Predişcan & Roiban, 2014).

The fact that strategy, or strategic management, is closely linked to change management is further pointed out by Errida and Lotfi (2021). The concept of "strategy" can be found in many models for implementing change. In one of the most well-known models, the 8-phase Kotter model, these words occur in step three (Kotter, 2015). In addition, it is essential to communicate this vision and strategy, so the assumption of its existence is necessary in this model. Another frequently used change model – McKinsey 7S – also includes the term

strategy (Kocaoglu & Demir, 2019). In this model, strategy is considered the so-called hard element of change. However, it is also essential to calculate the size of the change. In the case of small, incremental changes, it is not necessarily necessary to change the strategy. However, it is necessary to remember that the situation after the change must align with this strategy. Longaray et al. (2017) then characterize the PDCA model – plan, do, check, act. These models or procedures often consider the role of strategic management or planning and count on its significant support.

A distinctive feature of the current environment is the process management of organizations – after all, change itself is a process, as Kaes and Rinderle-Ma (2017) point out. Other authors then directly mention the individual factors that affect the organizational change process – for example, sufficient acceptance and communication of the considered change, adequate involvement of the change leader, or sufficient adaptation of the organizational structure and control processes. This case of change – organizational – therefore also interferes with another area of managerial duties – control – through the interconnection through the processes themselves. Nowadays, process management is an essential part of and especially the basis for effective change management in a dynamic environment (Whelan-Berry & Somerville, 2010).

Another very crucial area for the successful implementation of change is human resources management. People are the most critical factor in the successful implementation of any change. Many models of change work with employee resistance as the most significant factor influencing the entire process. Perhaps the most typical example of such a model is Maurer's model of resistance, which evaluates the whole process of change from the point of view of employees and their resistance to change the stereotype (Maurer, 2010). As an example of another model, we can use the Kübler-Ross model, which also defines the attitude of employees to the change process in five stages, or the typical Lewin model, which also evaluates the perspective of employees in detail (González et al., 2022).

Leadership is a very often mentioned term in HR in this context. Its importance in implementing changes is gaining in importance, as pointed out by e.g., Ford et al. (2021). However, it is essential to note that the leadership style (whether by the manager or the leader) is not the factor influencing successful change. As Policarpo et al. (2018) mention, combining multiple elements is essential. It is always important to look at the bigger picture and evaluate leadership as a whole, not as a style alone (Ignatieva et al., 2023). Maali et al. (2020) also point to the relationship between human resource management (or people leadership) and the successful implementation of change (although it focuses only on changes of a technical and technological nature). As an example of necessary effective practices, he mentions (in the field of HR) sufficient involvement of a change agent, leadership involvement, or enough resources for employee training.

In the context of Industry 4.0, other barriers can also be observed. These include the financial demands of implementing technologies related to this concept (Kamble et al., 2018), the increasing level of risk (Buer et al., 2018), the insufficient technological infrastructure of the organization (Xu et al., 2018), the low level of digital skills of employees (Petrillo et al., 2018) and, of course, employee resistance and ineffective change management (Müller et al.,

2018). Insufficient support from the government and its entities (Leng et al., 2020) or an insufficient business model (Chiappetta Jabbour et al., 2020) can also be considered a significant barrier.

1.1. Models of Change

When characterizing models of change, the Lewin model must be noticed. It is one of the oldest models of change management, dating back to the late 1940s. The basis of the model lies in Lewin's Field Theory, originally developed not to manage organizational change but to resolve social conflicts (Burnes, 2020). As Cummings et al. (2016) point out, the emergence of this model can be considered the beginning of modern change management. The steps are described as "unfreezing; organizational change; freezing" (Hussain et al., 2018).

Another proven model is Kotter's 8-phase model of change. Despite its high popularity, there needs to be more scientific discussion about its use in business practice (Pollack & Pollack, 2015). However, Caulfield and Brenner (2020) empirically point to the possibility of using the model outside the traditional business practice – in the non-profit sector. Moreover, the model's applicability in the 21st century is still high, as evidenced by Appelbaum et al. (2012), as no significant errors were found, and it continues to be recommended as a high-quality supporting methodological tool for implementing changes.

The ADKAR model is a model of the change process that can be targeted at the individual level. However, it is also applicable to larger groups of people or even to the entire organization. Its primary strength lies in identifying the weak point of the change process and finding the place where the change process fails, including the cause (Jaaron et al., 2022). The model itself is hidden behind the initial letters of its name. These are "Awareness, Desire, Knowledge, Ability, Reinforcement".

However, the literature offers a range of other models for managing organizational change, both at the enterprise and corporate levels. These models include the PDCA (Longaray, 2017), the Nudge model (Mullholand, 2023), the Kübler-Ross theory (Bregman, 2019), and the Satir model of growth (Leung et al., 2019).

2. Methodology

The main aim of the article is to evaluate the interdependence between barriers to implementing changes in micro, small, and medium-sized organizations in the Czech Republic. The secondary aim is to obtain a general overview of the currently addressed topics and concepts in connection with barriers and the implementation of changes in the categories of micro, small, and medium-sized enterprises, as well as to determine the geographical places where research on this issue is carried out.

The results of the questionnaire survey were used to meet the main aim. This survey was conducted online between September 2023 and November 2023 and addressed owners/executives/directors of micro, small, and medium-sized enterprises in the Czech Republic. The resulting sample includes 141 subjects. The outreach was done randomly and without a focus on a specific industry. The questionnaire consisted of 16 questions, 3 identifying (number of employees, age of the organization, subject of business) and the

remaining 13 addressing the implementation and management of company changes. Four questions were open-ended, ten were closed-ended, and two were half-open. The survey identified "poor communication (37)", "ineffective strategic management and planning (25)", "financial constraints (22)", "dysfunctional teamwork (20)" and insufficient leadership (17) as the most significant barriers to change adoption. Moreover, the barriers identified are consistent with the literature (Kocaoglu & Demir, 2019; Longaray et al., 2017; Ford et al., 2021; Maali et al., 2020; Kamble et al., 2018). Pearson's correlation coefficient was used to evaluate the interconnectedness of the observed barriers. This coefficient lies between -1 and 1, where -1 means negative correlation, 0 means no correlation, and 1 means positive correlation. The relevant formula for the calculation is offered by Mrkvička and Petrášová (2006); see below. MS Excel software was used for the analysis itself.

$$r = \frac{\sum X_i Y_i - n\bar{X}\bar{Y}}{\sqrt{(\sum X_i^2 - n\overline{X^2})(\sum Y_i^2 - n\overline{Y^2})}} \qquad (1)$$

The second aim is to identify other related areas and concepts associated with change management barriers in general, and keyword analysis based on the topics discussed in the contributions of the Web of Science scientific database was used for its fulfillment. To identify the corresponding scientific contributions, the PRISMA 2020 methodology was followed (PRISMA, 2021). The research took place on December 10, 2023. The whole process is shown in Figure 1.
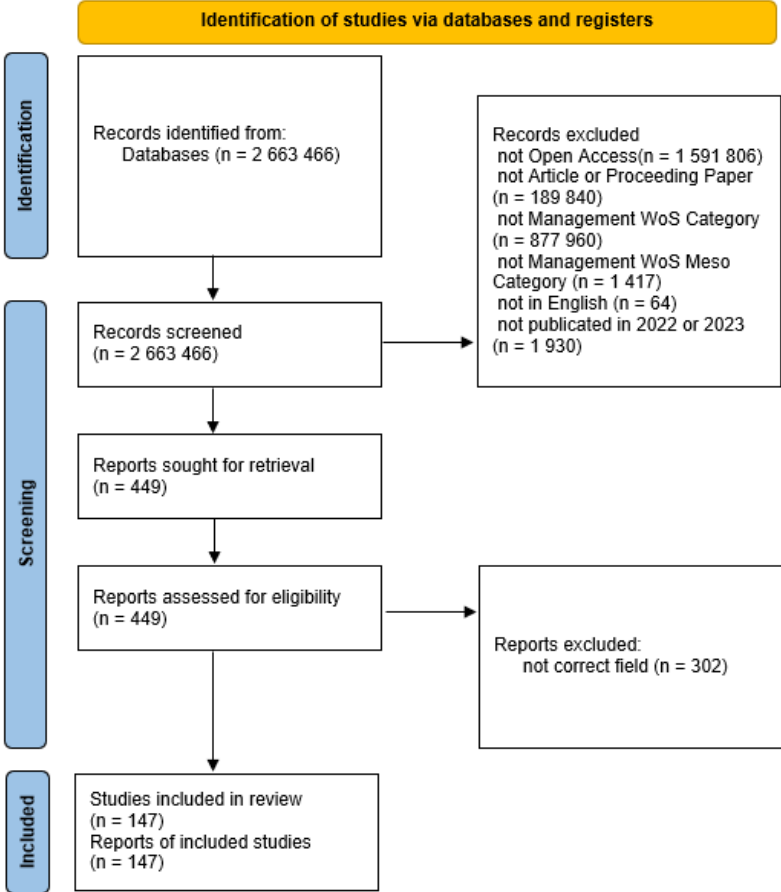
Figure 1. PRISMA 2020 diagram (PRISMA, 2021)

The main criterium is "Topic" defined by the sentence "Barrier" OR "resistance" OR "reason" AND "change" OR "change management" AND "success" OR "implementation" AND "SME" OR "SMEs". Other restrictive criteria were then applied. The first was the availability of Open Access. This was followed by a restriction in terms of the type of contribution to "Article" or "Proceeding Paper". After that, contributions were limited to the "Management" area only, and the "Citation Topics Meso" field was also defined as "Management". In a disproportionate series, there was a restriction in terms of language, with English being the only language chosen. In the end, the time aspect was defined, where only contributions from 2022 and 2023 are worked with to ensure the topics' highest possible level of topicality. Based on the study of the titles and abstracts of the remaining papers, 147 of them were selected for visualization. The condition was that there must be a link with change or change management.

3. Results

3.1. Main Aim of the Paper

Selected barriers to implementing changes in SMEs are described in more detail in Chapter 2 – Methodology. To give you a better idea of the examined sample, the authors present essential descriptive characteristics, such as the division of the sample according to size, the age of the company, and the most frequently mentioned fields of business.

The category of micro-enterprises employing not more than 10 employees is the most represented – precisely 79 enterprises. The class of small enterprises with a maximum of 50 employees is represented by 38 organizations and medium-sized enterprises by 24 companies.

Organizations that have been on the market for more than 15 years have the highest representation in the sample observed (88). The second most represented group has been on the market for 10-15 years (22). As a result, it can be assumed that businesses have enough experience with change. On the other hand, enterprises that have not been active on the market for even a full year are not represented at all.

Construction has the most frequent representation in terms of business sector (13), followed by manufacturing and metalworking enterprises (12) and retail trade (10). Services (accounting and economic consulting – 11), web content, and website creators (10) are also strongly represented. At the same time, the companies in the examined sample most often implement operational changes (46.1%), followed by medium-term changes (21.3%) and strategic changes (12.1%). The rest of the companies cannot determine the changes' nature or have practically not encountered them. However, 59.5% of businesses say that changes are successfully completed and adopted, and only 8.1% say they are not. The remaining share (32.4%) cannot determine the prevailing end of the change process.

The Pearson correlation coefficient method was chosen to observe the selected barriers' interdependence to implement changes successfully. These barriers are "poor communication (PC); ineffective strategic management and planning (SMP); financial constraints (FC); dysfunctional teamwork (TW); insufficient leadership (IL)". The result of the correlation analysis is shown in Table 1.

Table 1. Correlation analysis

	PC	IL	TW	FC	SMP
PC	1.00	-0.04	0.22	0.17	0.13
IL	-0.04	1.00	0.19	-0.09	-0.04
TW	0.22	0.19	1.00	0.12	-0.04
FC	0.17	-0.09	0.12	1.00	0.17
SMP	0.13	-0.04	-0.04	0.17	1.00

There is almost no correlation (-0.04) between communication and leadership factors, suggesting that these factors are not strongly related. On the other hand, a moderately strong correlation (0.22) is observed between the factors of communication and teamwork, based on which it can be inferred that by improving communication, we can achieve a synergistic effect and simultaneously remove the barrier of non-functioning teamwork. The communication factor is also positively correlated with the financial resources factor (0.17), so it is possible to assume that the improvement of one aspect will affect the other. The question of the link between planning, strategic management, and communication is also expressed by a positive correlation coefficient (0.14). The leadership factor is positively correlated only with improved teamwork (0.19) and negatively correlated with all others. Notably, the team collaboration factor is positively correlated with an organization's budget (0.12). On the other hand, an expected correlation was found between the strategic management and planning factor and the budget/financial resources of the enterprise (0.17).

However, the communication factor is the strongest. It can, therefore, be assumed to be the main barrier to successfully implementing changes. At the same time, by eliminating deficiencies in communication, a synergistic effect can be achieved, and other barriers can be eliminated. We can also describe the factor of teamwork and financial resources as vital (both have only one negative correlation). However, the basis for removing even these two barriers is communication in the first place. Strategic management and planning are not very important barriers. Leadership is even positively correlated with only one factor – teamwork – but this is where this discipline finds its use, so it cannot be said that it does not have its place in the processes of change based on negative correlations and that it is not a significant barrier in the event of its deficiency.

3.2. Secondary Focus of the Paper

The PRISMA 2020 process was used to meet the secondary aim, and 147 contributions from the Web of Science scientific database are being processed. The primary tool for achieving this goal is keyword analysis with visualization using the VOSviewer tool. The result of the study is shown in Figure 2. Two keywords – change and change management – were excluded from this analysis, as their connection to this topic is de facto determinative. At the same time, only keywords with a higher frequency of occurrence than 5 were used for a better graphic interpretation.

Figure 2. Keyword analysis (VOSviewer)

The graphical display of the keyword analysis primarily shows the division of words into 4 clusters. The first deals with the resources for change and, at the same time, with the company's performance level. The importance of knowledge management is also worth mentioning. In the second cluster, the role of leadership, strategy, and, last but not least, the organization's management can be observed. The third cluster can then be linked to technology, the braking and driving forces of change, and the (business) model needed to implement change. The last observed cluster also includes the concept of strategy and knowledge. Therefore, it can be eliminated and incorporated between clusters 1 and 2. Table 2 provides the absolute frequencies of the most frequently detected keywords and topics related to the change.

Table 2. Top keywords

Keyword	Absolute frequency	Relative frequency
Performance	48	9.76%
SME	37	7.52%
Impact	26	5.28%
Management	26	5.28%
Knowledge	19	3.86%

From the above, it is clear that in connection with the management and implementation of changes in organizations, the most frequently discussed issues are the performance of the company, the impact of the change itself on the company, the management of the

organization itself, and the effects on this management, and last but not most minor; it is also necessary to consider knowledge. These topics can be described as the most frequently discussed about change management at the moment. Notably, neither new technologies nor Industry 4.0 are among these topics. In general, companies are more focused on impact assessments and their performance than on the substantive content of the change itself.

For the sake of completeness, Figure 3 is offered, which shows the geographical layout of the monitored posts.
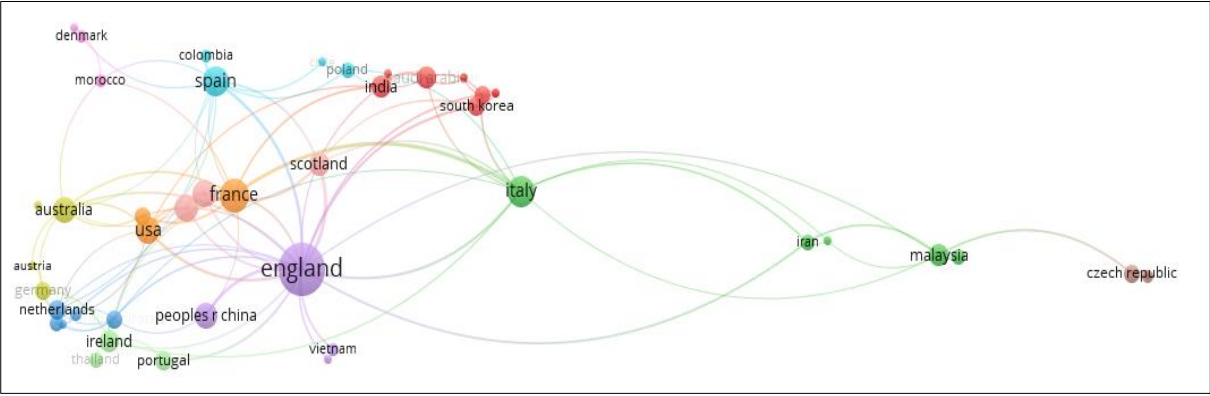
Figure 3. Observed countries (VOSviewer)

Among the monitored contributions related to the topic, it can be observed that most of them (34) come from England. France (14 contributions), Italy (12 contributions), Spain and Indonesia (both 11 contributions), Finland, Sweden, and the United States (9 contributions) are in second place. Indonesia, in particular, can be seen as a minor surprise. On this basis, European countries are addressing the issue of change in high-level enterprises and trying to address the issue of successful implementation and change management.

Based on this observation, it can be reasonably assumed that most of the institutions the authors work in will be located in the British Isles (as Scotland and Ireland are among the most frequently observed countries) or in France or Italy. A specific list of the most represented institutions is provided in Table 3.

Table 3. Observed institutions

Institution	Absolute frequency	Citations	Country
Paris school of business	3	61	France
Neoma business school	3	38	France
University Vaasa	3	20	Finland
University of Essex	3	15	Great Britain (England)
Queen Mary University London	3	11	Great Britain (England)

Based on the analysis, the most frequently cited organizations come from France and Great Britain, specifically from England. It cannot be said that this is an unexpected fact. However, these entities most likely offer a significant background and support for analyses of change management, its impacts, and its impact on the functioning of companies. Their outputs receive much attention in the scientific sphere.

4. Discussion

The biggest change companies are introducing, not only at the micro, small, and medium-sized level, is Industry 4.0. Due to the dynamic environment, it is desirable to introduce modern technologies as quickly as possible. In addition, businesses across various industries can adopt selected ones, e.g., Clouds, digitalization, or cyber-related technologies (Vimal et al., 2023). Moreover, new technologies do not necessarily apply only to micro, small, and medium-sized organizations but also to large enterprises.

Barriers related to introducing new technologies are more specific than classic barriers to change. In the research, poor communication is considered the main barrier; after that, ineffective strategic management and planning, financial constraints, dysfunctional teamwork, and insufficient leadership. Govindan and Arampatzis (2023) define barriers related to Industry 4.0 and heavily address the issue of leadership, vision and strategy, and financial resources. On the contrary, in contrast to the classic approach to change, where employee resistance at the individual level is not one of the most significant barriers according to research, this barrier is at the forefront here. Attiany et al. (2023) further emphasize the importance of strategy and the role of strategic management. They also cite employee resistance as another critical factor. Erena et al. (2022) also state that management support and leadership are essential factors for implementing change and innovation. In addition, they mention the role of knowledge.

The issue of communication of change is an essential factor, or barrier, for businesses in the Czech Republic. Mortimer and Laurie (2017) also point out the importance of removing this barrier on a specific case of companies from the UK when implementing marketing changes. Maurer et al. (2023) also point out that communication is an essential factor during change while drawing attention to the fact that change can affect communication flows. It is, therefore, important to pay maximum attention to this barrier even during organizational change. Hubbart (2023) even considers the communication itself and the setting up of communication flows to be the first step that should be set up. At the same time, communication should permeate all phases of the change process, thus eliminating this barrier. The author also notes that leadership can be an excellent tool for effective communication, as Gray et al. (2023) also points out.

May (2023) reminds us of the importance of leadership but also mentions corporate culture as one of the main determinants of change and innovation. As part of corporate culture, the author understands teamwork, the last of the barriers identified by this research.

From the above, it is clear that micro, small, and medium-sized enterprises in the Czech Republic face the same barriers as companies in other countries. The role of communication in the process of change is indisputable, and leadership is a very effective procedure for its effectiveness. The further observed barriers are addressed; their place in the change process still needs to be more cohesive. In addition, the literature highlights other essential factors, such as corporate culture or knowledge. The question is whether companies in the Czech Republic do not consider these factors important or whether addressing a more extensive sample of respondents would be necessary to observe them.

5. Conclusions

The main aim of the article was to evaluate the interdependence between barriers to implementing changes in micro, small, and medium-sized organizations in the Czech Republic. The secondary aim was to obtain a general overview of the currently addressed topics and concepts in connection with barriers and the implementation of changes in the categories of micro, small, and medium-sized enterprises, as well as to determine the geographical places where research on this issue is carried out.

Pearson's correlation coefficient was used to meet the first aim. The analysis found that communication is the most critical barrier to effective implementation of change, as it was negatively correlated with only one other barrier – teamwork. However, two other barriers were negatively correlated with only one other, namely teamwork and financial resources. However, it is clear that communication is the basis for successful change management, and by incorporating it, other significant barriers can be removed. On the other hand, it was found that leadership is positively correlated with only one factor and, therefore, cannot be given as much weight.

The second aim of the paper was fulfilled mainly thanks to the analysis of keywords from the contributions of the Web of Science scientific database using the PRISMA 2020 diagram. The study found that performance, impact, or knowledge are the most frequently inflected terms in connection with change. In addition, most research on this topic occurs in Great Britain and France. In addition, the analysis shows that the issues of the impact of the change on the company and its performance are more often raised, not on the factual content of the change itself.

Finally, an overview of this research's limitations and possible future research directions is offered. The research was limited in terms of time (September 2023 – November 2023), and the search for posts in the database took place for only one day. Also, the research was limited in location – to the Czech Republic and the online environment. Future research may move toward observing other possible barriers to implementing changes in the Czech Republic as an extension of this research and their other influences or the level of power themselves.

Conflict of interest: none.

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Project Management in the Time of VUCA: Threat or Opportunity?

Jana KOSTALOVA[1]*, Radek DOSKOCIL[2], Lenka SIRANOVA[2] and Branislav LACKO[2]

[1] University of Pardubice, Pardubice, Czech Republic; jana.kostalova@upce.cz

[2] Technological University Brno, Czech Republic; Radek.Doskocil@vut.cz, Lenka.Siranova@vut.cz; lacko@fme.vutbr.cz

* Corresponding author: jana.kostalova@upce.cz

Abstract: This study addresses the "projectification of society" and its alignment with the VUCA framework (Volatility, Uncertainty, Complexity, Ambiguity). Four widely used international project management standards—PMI, IPMA, PRINCE2, and PM[2]—are evaluated for their suitability in the VUCA environment. The research employs a multi-criteria approach, specifically the Weighted Sum Approach method, considering factors like volatility, uncertainty, complexity, and ambiguity. The selected standards are scrutinized based on their adaptability to VUCA challenges, with a focus on PMBOK, IPMA, PRINCE2, and PM[2]. The seventh edition of the PMBOK has been evaluated on the first position. The study emphasizes the crucial role of selecting an appropriate project management standard for success in navigating the dynamic VUCA world. The results confirmed this and brought a number of recommendations for managing projects in a VUCA environment.

Keywords: project management; VUCA; project management standard; decision making; WSA method

JEL Classification: O22

1. Introduction

A number of studies confirm the general trend of the so-called "projectification of society", indicating the increasing number of changes in society and the effort to manage these changes with the help of methods and tools of project management and thus improve the ability to manage these changes, not to be in the wake of these changes (Wagner, 2022; Fridgeirsson et al., 2021). This changing environment was labelled VUCA – Volatility, Uncertainty, Complexity, Ambiguity. The ambition of this term is to depict the current development of society, which is influenced by very dynamic technological but also social development, climate changes under conditions of a high degree of interconnectedness, uncertainty, riskiness, different perceptions of coming changes by different groups in society and high variability of conditions.

In this context, it is possible to define research questions regarding the readiness of international standards and methodologies of project management to actually offer methods and tools that will enable successful project management in this changing and uncertain environment.

The article deals with the multi-criteria approach for project management standards evaluation, based on VUCA dimensions (Minciu et al., 2020). VUCA, which is an acronym for Volatility, Uncertainty, Complexity and Ambiguity, is a comprehensive model for understanding the challenges and dynamics of today's business environment. This framework (as introduced by Minciu et al. (2020)) forms the basis for the research conducted in this paper.

Volatility points to the rapid and unpredictable changes that projects often face, which require adaptive and agile standards. Uncertainty highlights unpredictability and emphasizes the need for standards.

Complexity represents the totality of various factors in project implementation. Finally, ambiguity recognizes the presence of unclear or conflicting information that can lead to inconsistencies in project objectives.

Choosing an appropriate project management standard is an important decision that should be carried out professionally (Golpîra & Rostami, 2015; Hübner et al., 2018). The wrong choice affects the success of the project (Moura et al., 2023).

Currently, there are four international project management standards and methodologies, operating globally or within the Europe, developed by international project management associations. Project Management Institute (PMI) from USA, International Project Management Association (IPMA), founded and operating mainly in Europe, Association for Project Management (PRINCE2) from Great Britain and also operating mainly in Europe and the new PM² Methodology by PM² Alliance from the environment of institutions The European Union with the ambition to operate in Europe.

These associations try to reflect developments and gradually update their standards and include new procedures, methods, recommendations. The PMI core standard is based on a process approach and is presented in the PMBOK Guide – currently in the 7th edition (PMI, 2021). A number of other standards are available at the level of Program Management, Portfolio Management, Risk Project Management, Organizational Project Management, etc. The IPMA standard is based on a competency approach, i.e. it recommends appropriate competencies of project managers for successful project management and currently offers three standards: IPMA individuals competency Baseline, ICB version 4, The IPMA Project Excellence Baseline for excellence projects and the IPMA Organizational Competence Baseline for organizations (IPMA World, 2022). In the Czech Republic, a national version of the standard was created, the International Project Management Standard according to IPMA ICB v. 4 (IPMA CZ, 2022; IPMA World, 2022). The Project IN Controlled Environments 2 (PRINCE2) standard is a process and method-oriented approach and (Axelos, 2015; PRINCE2, 2022). The PM² methodology is newly presented in the European area, which also has a process-methodical approach and presents as its advantage the availability of the methodology ("PM² Project Management Methodology Guide 3.1") and all artefacts for free with the aim of expanding skills in the field of project management as much as possible (PM² Alliance, 2022).

The main goal of the article is to evaluate the selected project management standards in terms of their suitability for VUCA time.

2. Methodology

The research methodology is based on the fundamental principles of scientific work, ensuring a rigorous, systematic approach. Central to methodology is the alignment of selected research methods with a clearly defined research goal, ensuring that every methodological choice directly contributes to our overall objective. These principles were applied in the context of general project management theory with a focus on multi-criterial decision making (MCDM) approaches based on WSA (Weighted Sum Approach) method.

2.1. Expert Approach

The expert approach involves gathering insights and opinions from qualified individuals, typically experts in the relevant field. In the context of research or decision-making, experts, such as professionals, academics, or practitioners, are nominated to form an expert group. Their collective knowledge and expertise contribute valuable perspectives to inform and enhance the research process, ensuring a more comprehensive and informed outcome. This approach leverages the depth of experience and specialized insights of experts to enrich the understanding of complex topics or challenges (Hohmann et al., 2018)

For collecting of data, we used expert approach. Members of international associations, university lecturers and researchers in area of project management and experts from practice have been nominated to expert group.

Three experts with more than ten years of experience in the field of project management from the academic environment and the private sector were selected for the assessment using this method. The evaluation took place on a five-point scale, where 1 meant the lowest ability of the relevant international standard to contribute to the specified criterion and 5 meant that the given standard greatly helps the fulfilment of the given criterion in project management in practice.

2.2. MCDM Problem and WSA Method

There exist three main steps in utilizing MCDM problem involving numerical analysis of a set of discrete alternatives:

- Determining the relevant criteria and alternatives.
- Attaching numerical measures to the relative importance (i.e., weights) of the criteria and to the impact (i.e., measures of performance) of the alternatives in terms of these criteria.
- Processing the numerical values to determine the ranking of each alternative.

There are many computer software, e.g., the Expert Choice (Expert Choice, 2021), Criterium Decision Plus (*Criterium DecisionPlus 3.0*, 2019), which could be used as a tool for solving MCDM problems. MS Excel was sufficient to solve our decision-making problem.

In MCDM problem are the alternatives usually denoted as A_i (for $i = 1,2,3,\ldots,M$) and criteria as C_j (for $j = 1,2,3,\ldots,N$). It is assumed that for each criterion C_j, the decision maker has determined its importance i.e. weight (W_j) for which the following formula is always true:

$$\sum_{j=1}^{N} W_j = 1 \qquad\qquad (1)$$

The WSA method is based on the construction of a linear scale utility function from 0 to 1. The worst alternative (d_j) according to the given criterion will have a utility of zero, the best alternative (h_j) utility one and the other alternatives will have utility between the two extremes.

It means that the elements y_{ij} must be replaced by the input criteria when applying this method matrix by the values of $´y´_{ij}$, which will represent the utility of the alternative A_i when evaluated according to criteria C_j. The values of $y´_{ij}$ can be obtained for the maximization criteria according to the following formula (Stopka et al., 2020):

$$y´_{ij} = \frac{y_{ij} - d_j}{h_j - d_j} \qquad\qquad (2)$$

The total benefit of the alternative X_i can be calculated as a weighted sum of partial benefits according to individual criteria (Stopka et al., 2020):

$$u(A_i) = \sum_{j=1}^{M} w_j\, y´_{ij} \qquad\qquad (3)$$

Alternatives can be then ranked according to decreasing utility values $u(A_i)$.

3. Results

In the case study the WSA method is applied as a suitable method from the area of multi-criteria decision making for evaluation of the selected project management standards to improve success of management of projects in the time VUCA.

3.1. The Criteria Identification of the Affected Criteria for Client Creditworthiness Assessment

Four basic VUCA dimensions – Volatility, Uncertainty, Complexity, Ambiguity, were used as input evaluation criteria. Their meaning in context of project management is follows (Staden, 2023):

- Volatility

Volatility in the context of project management is defined mainly by the changing environment in which projects are planned and implemented. Compared to the past, this environment is changing very rapidly and fundamentally. This is due, for example, to new developments in technology (e.g. the digital transformation phenomenon), a dynamic market environment (e.g. the globalisation factor) or a knowledge-based economy (e.g. knowledge as a factor of production). The changing environment is thus a natural consequence of the evolution of society as a whole and the economy adapting to it. Such a changing environment is not only threatening, but in reality, brings a number of problems and issues that must be solved. Volatility makes it increasingly difficult for project managers to distinguish between what is urgent and what is important. The key to success is the application of agile management principles to projects. Volatility increases the importance of effective risk

management in projects. In a dynamic and rapidly changing environment, it is critical to identify potential risks early and develop strategies to mitigate or prevent them.

- Uncertainty

Uncertainty in project management is mainly due to the inability or limited ability to use data, information and knowledge from past projects in future project plans. This is due to the fact that it was obtained under different circumstances (see the changes in the environment mentioned in the context of the Volatility factor). It can only be partially used as a basis for future projects. It follows logically that if there is not sufficient quality material on past projects, it is difficult to assess their current status, let alone predict their future development. All this is affected by uncertainty. All of this is affected by uncertainty and change, which comes in far greater frequency and in many forms, out of step with previous experience. The greater the lack of data, information and knowledge, the greater the uncertainty. This is linked to difficulties in planning and decision-making. The application of risk management in projects is the key to success (Fridgeirsson, Ingason, Bjornsdottir, et al., 2021; Fridgeirsson, Ingason, Jonasson, et al., 2021). The application of risk management is a key element for managing this uncertainty, enabling the identification and management of potential risks and opportunities in a project.

- Complexity

Complexity in project management is characterised by its complexity - that is, the complexity of the individual elements and the links between them. In such a complex project "system" it is very difficult to identify key components and to implement adequate decisions. The key to success is the application of knowledge management principles in projects (Iyer & Banerjee, 2019). Knowledge management will ensure both the linkages between the project elements and the overall view. The scenario method and sensitivity analysis are recommended as appropriate methods. It is crucial for a project manager to have the broadest possible knowledge in the context areas that are related to the project in order to understand the complexity of project management. Not only knowledge, but also soft skills can help in managing project teams in such a complex environment, as communication and leadership of the project team will be more demanding and more crucial than in projects in the past.

Soft skills are critical in today's projects because they promote effective communication, teamwork, and adaptability, which are essential elements for successfully addressing complex and dynamically changing challenges.

- Ambiguity

The ambiguity phenomenon of project management is actually characterized by the impossibility of a precise statement on the various aspects of the project. Typically, for example, to the questions: in what state is the project? When will the project be completed? What will be the final project budget? The impossibility of giving an exact answer is due to the mix of all the dimensions described above, and in addition to the individuality of the respondents (different and often conflicting views of the persons involved). The key to success is defining the "conditions of validity", i.e. testing the stability of the solution, very

precisely monitoring the status of the project during its life cycle. That is, the application of sensitivity analysis or the scenario method in the context of project quality management.

3.2. Determining the Alternatives

The four most frequently used world project management standards were selected for evaluation (PMI, IPMA, PRINCE2, PM²). In addition to the mentioned international project management standards, there are a number of national, corporate and other institutional standards in the field of project management. However, the selected four standards are generally used, most widespread, continuously updated and described in detail with wide international use, which is not the case for the others. Therefore, these four were selected for the subject analysis of this article.

3.3. Multi Criteria Evaluation based on WSA Method

Inputs data for multi-criteria evaluation are presented in the criterion matrix (see Table 1).

Table 1: The criterion matrix

Criteria/ Subcriteria / Alternative	Volatility		Uncertainty		Complexity		Ambiguity	
	Agility	Issues	Risks	Changes	Soft skills	Context areas	Project status	Quality
PMI - PMBOK 7th Edition	5	5	4	5	2	1	4	4
IPMA - ICB version 4	3	3	4	5	5	5	3	4
PRINCE2 – APM Body of Knowledge 7th	4	5	3	5	1	1	5	5
PM²– PM Methodology 3.1	1	3	4	3	2	1	2	3

Note: All criteria and subcriteria in the table 1 are *"max"* type (beneficial), i.e. the higher the value the better.

The hypothetical determination of the ideal (the best) alternative and the hypothetical basal (the worst) alternative is presented in the Table 2 in their last two rows.

Table 2: The criterion matrix and identification of the worst (d_j) and the best(h_j) alternative

Criteria/ Subcriteria / Alternative	Volatility		Uncertainty		Complexity		Ambiguity	
	Agility	Issues	Risks	Changes	Soft skills	Context areas	Project status	Quality
PMI - PMBOK 7th Edition	5	5	4	5	2	1	4	4
IPMA - ICB version	3	3	4	5	5	5	3	4
PRINCE2 – APM Body of Knowledge 7th	4	5	3	5	1	1	5	5
PM²– PM Methodology 3.1	1	3	4	3	2	1	2	3
h_j	5	5	4	5	5	5	5	5
d_j	1	3	3	3	1	1	2	3

The calculation of the standardized criterion matrix, aggregate utility function and the ranking of the alternatives presented the Table 3.

Table 3: The standardized criterion matrix, the calculation of aggregate utility function and the ranking of the alternatives

Criteria/ Subcriteria / Alternative	Volatility		Uncertainty		Complexity		Ambiguity		$u(A_i)$	Rank
	Agility	Issues	Risks	Changes	Soft skills	Context areas	Project status	Quality		
weights	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125		
PMBOK 7th Edition	1	1	1	1	0.25	0	0.67	0.5	0.67	1
ICB version 4	0.5	0	1	1	1	1	0.33	0.5	0.66	2
PRINCE2 – APM Body of Knowledge 7th	0.75	1	0	1	0	0	1	1	0.59	3
PM² – PM Methodology 3.1	0	0	1	0	0.25	0	0	0	0.15	4

4. Discussion

Figure 1 presents the specific priority values of the alternatives and their final ranking. The seventh edition of the PMBOK (Project Management Body of Knowledge) has the highest utility function value, reaching 0.67, which is described in more detail in Table 3. Based on this value, the PMBOK 7th Edition is evaluated as the best alternative. The second ranked alternative is ICB (International Competence Baseline) Version 4. The third position was awarded to the PRINCE2 (Projects IN Controlled Environments) standard presented in APM Body of Knowledge 7th Edition, while the last position was occupied by the PM² (Project Management Methodology 3.1) standard. These results provide valuable insight and can assist project managers and organizations in selecting the most appropriate project management methodology for their specific needs and objectives in current changeable world.
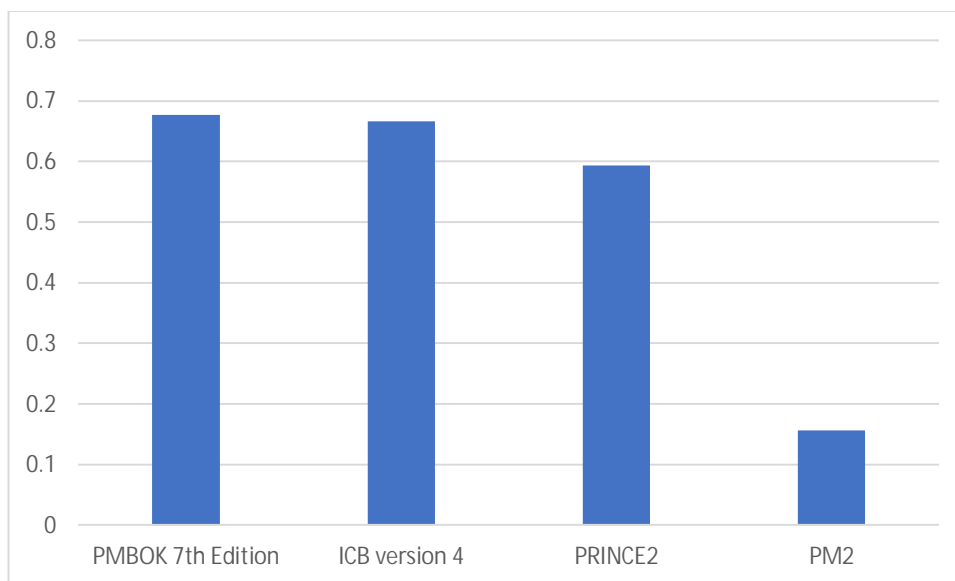
Figure 1: Graphical representation of Project Management Standards Evaluation

VUCA places great demands on high-quality and well-managed currency management throughout the project, from the pre-project stages to the end of the project. The issue of changes must be addressed not only at milestones, but at every working meeting of the project team. It is necessary to prepare for a large number of changes, thoroughly analyze the reasons, assess the benefit and impact of the change and ensure the implementation of the necessary, agreed changes. Of course, this process needs to be carefully documented. With regard to VUCA situations, it is important to add certain time and cost reserves to current projects at the very beginning, which will help to manage the resulting currencies effectively. The VUCA world does not wish megalomaniacal long-term projects. These are better avoided at present. Even big projects currently have and will have problems. Greater success will be achieved by dynamic planning and managing smaller, shorter and better manageable projects grouped into programs to cover large areas.

VUCA impacts require a high-quality analysis of project objectives, in which "stability" issues must also be considered selected goals during the project implementation time. If it is found that the goal is changing, it is necessary to consider whether it is not more efficient to stop the project and define a new project with regard to the change of goal, using the results of the stopped project to date, see e.g. STAGE GATE MODEL (Cooper, 2008; Grolund et al., 2010).

The waterfall model is not very suitable for the VUCA world and it is better to use an agile approach to project management. But this does not mean the suppression of planning processes in project management. Even in agile project management approaches, even increased attention must be paid to planning activities and prediction processes must be strengthened (Bartoska et al., 2013). It has already been shown that the waterfall model is not very suitable for, for example, R&D projects. Due to the high level of uncertainty in R&D, it is better to use an agile approach to project management (Koucka et al., 2021). This is currently evident in projects in the development of e.g. modern weapons (Dybek & Glodzinski, 2023) and in projects implementing information and communication technologies included in Industry 4.0 (Özbebek Tunç & Aslan, 2019; Bakes et al., 2022).

Choosing a team that will support multi-functional cooperation is also a beneficial step to adapting to the VUCA environment, team members will have diverse skills and perspectives, which enables a more comprehensive approach to solving problems in complex and uncertain situations. They will be ready to constantly learn and improve, think about the progress and results of the project and perform feedback, lessons learned, think about unpredictable scenarios. The human factor is also important in team management, leadership in a VUCA environment requires flexibility and the ability to inspire and lead teams through uncertainty. Leaders should be adaptable, open to feedback and able to make informed decisions quickly (McGrath & Kostalova, 2020).

5. Conclusions

The study concludes that the "projectification of society" and the evolving VUCA (Volatility, Uncertainty, Complexity, Ambiguity) framework present significant challenges and opportunities for project management. Through a thorough evaluation of four international project management standards—PMI, IPMA, PRINCE2, and PM[2]—using the

Weighted Sum Approach (WSA) method, the research identifies the PMBOK 7th Edition as the most suitable standard for navigating the dynamic VUCA environment. The findings underscore the importance of selecting an appropriate project management standard, to enhance the success of projects in the face of VUCA challenges.

The discussion emphasizes key considerations for project management in a VUCA world, including the need for effective change management, dynamic planning, and the adoption of agile approaches. The study suggests that large, long-term projects may face difficulties in the VUCA world, and success may be better achieved through dynamic planning and the management of smaller, more manageable projects grouped into programs.

Furthermore, the study highlights the significance of team dynamics and leadership in a VUCA environment. It recommends building teams with diverse skills and perspectives, fostering constant learning and adaptability, and promoting effective communication. Leadership in a VUCA environment requires flexibility and the ability to make informed decisions quickly.

To effectively manage projects in the VUCA world, it is essential to have an agile mindset, be able to adapt to change quickly and employ sound risk management strategies.

Project managers should pay attention to stakeholder management and maintaining open and transparent communication.

In conclusion, the research provides valuable insights for project managers and organizations, guiding them in the selection of project management methodologies that align with the challenges and dynamics of the VUCA world. The findings contribute to the ongoing discourse on adapting project management practices to the evolving nature of societal and business environments.

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From Tradition to Recognition: Exploring pre-1989 CSR in Slovakian Agriculture

Jana KOZÁKOVÁ[1], Renata SKÝPALOVÁ[2], Ivan HOLÚBEK[1], Radovan SAVOV[1] and Tomáš JEŘÁBEK[2]*

[1] Slovak Agricultural University in Nitra, Slovak Republic; jana.kozakova@uniag.sk; ivan.holubek@uniag.sk, radovan.savov@uniag.sk

[2] AMBIS college, Prague, Czech Republic; renata.skypalova@ambis.cz, tomas.jerabek@ambis.cz

* Corresponding author: tomas.jerabek@ambis.cz

Abstract: Paper aims to investigate the socially responsible activities undertaken before the political changes of 1989 using the example of JRD Krajné, Slovakia. By examining their CSR practices, the study sheds light on the organic development of responsible business initiatives within the region's business culture at the time and provides insights for businesses across sectors to incorporate responsible practices into their current operations. Structured interviews were used as the primary data collection method, with Ing. Vojtech Tĺčik, the former chairman of JRD Krajné, serving as the interviewee. A set of 11 open-ended questions captured insights into the cooperative's socially responsible activities before 1989. The results reveal that JRD Krajné engaged in diverse socially responsible activities, focusing on social welfare, environmental stewardship, and economic responsibility. The paper contributes to the literature by offering a detailed exploration of JRD Krajné's historical CSR practices, showcasing how businesses in Slovakia demonstrated commitment to well-being before formal CSR practices were widely recognized. It highlights the importance of recognizing and preserving historical CSR practices as valuable precedents for shaping contemporary CSR strategies. This study provides insights for businesses aiming to foster sustainable practices and contribute to holistic societal development not just across agribusiness sector.

Keywords: corporate social responsibility; historical CSR practices; agribusiness

JEL Classification: M14; P31; Z13

1. Introduction

The classic economic theory of the 19th century, as noted by Vrabcová (2021), was rooted in the concept that entrepreneurial activity in a competitive market is driven by the goal of profit maximization. However, this approach sometimes led to contradictions, as short-term profit maximization does not always equate to the long-term sustainability of a business. Furthermore, Vrabcová (2021) highlights that with time, the corporate goal-setting process began to integrate social and environmental aspects. This integration gave rise to the idea of a global corporate objective: achieving sufficient profit while fostering the company's long-term development, and simultaneously respecting social and ecological standards. Elaborating on this, Kislingerová et al. (2023) emphasize that for several years, it has become evident, particularly in developed countries, that public demand—manifested through

political and consumer preferences—is steering companies to recognize environmental values. This shift, supported by long-term electoral support for environmentally conscious political formations, has led to the creation of extensive environmental and climate protection legislation. Kislingerová et al. (2023) also point out that in assessing corporate performance, traditional financial analysis indicators, such as profitability, liquidity, activity, debt, and capital market indicators, are still predominantly used. However, these traditional approaches seem insufficient for the transformed objectives of advanced economies toward circularity and overall sustainability.

The 2030 Agenda for Sustainable Development, universally embraced by United Nations member states in 2015, constitutes a collective roadmap for advancing global peace and prosperity. It is a comprehensive vision aimed at ensuring the well-being of both humanity and the planet, spanning present and future generations. At its core lie the 17 Sustainable Development Goals (SDGs), serving as an impassioned rallying call for action, binding together nations, both advanced and developing, under the umbrella of a global alliance. This framework underscores the imperative of eradicating poverty and various forms of deprivation while concurrently pursuing strategies to enhance healthcare and education, reduce disparities, foster economic growth, all while addressing the urgent challenges of climate change and preserving the ecological health of our oceans and forests (United Nations, 2015). The adoption of the Sustainable Development Goals marked a pivotal moment in the international community's commitment to shaping the course of the world. Convened at a momentous United Nations General Assembly summit in September 2015, this assembly attracted participation from over 150 heads of state and government, charting a transformative path for global development (United Nations, 2015). These goals (Figure 1), designed to guide the trajectory of societies worldwide over the ensuing 15 years, were underpinned by a preamble articulating the fundamental dimensions that underlie the contemporary notion of sustainable development. This foundational construct is comprised of three essential pillars, subsequently augmented by two more: People, Planet, Prosperity, Peace, and Partnership (Cheng et al., 2022).
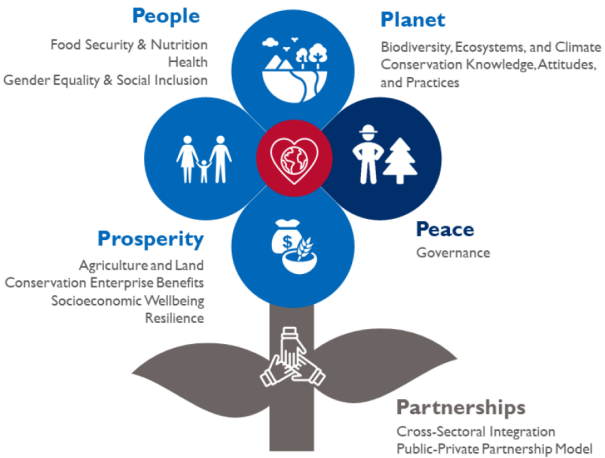
Figure 1. HEARTH MERL Framework: People, Planet, Prosperity, Peace, and Partnerships. (Cheng et al. (2022))

Corporate social responsibility, as defined by Kašparová (2011), signifies a paradigm wherein companies, in tandem with their primary profit-making mission, systematically monitor and mitigate the environmental and societal impacts of their operations. This approach seeks to diminish adverse effects and amplify beneficial outcomes. Yet, the full benefits of this concept often remain unrealized until a company's activities are transparently disclosed, after which the company may experience limited gains, chiefly in the form of cost savings or, optimally, strategic philanthropic endeavors (Kašparová, 2011). According this, Moldan (2020) highlights a persistent incongruity between the escalating trajectory of economic growth and the concomitant escalation in environmental burdens. Despite the pervasive pursuit of economic growth as the quintessential development objective worldwide, there has only been partial decoupling, whereby economic and environmental trends diverge but environmental burdens persist or even escalate, as corroborated by comprehensive data. Decoupling, though an aspiration for environmental sustainability, appears to be an elusive objective (Moldan, 2020).

In recent years, Corporate Social Responsibility (CSR) has gained significant prominence as a vital aspect of business conduct, emphasizing an organization's commitment to economic, societal and environmental well-being. The relevance of CSR lies in its potential to drive sustainable development, foster positive stakeholder relationships, and enhance a company's reputation while contributing to "public good". However, until CSR has garnered widespread attention in the contemporary business landscape (primarily after multinationals enter the market), the historical CSR practices of enterprises, especially within the context of pre-1989 Slovakia, remain relatively underexplored.

Corporate Social Responsibility (CSR) is a multifaceted concept that encompasses a company's commitment to conducting business in an ethical, socially responsible, and sustainable manner (Carroll, 1999; Dahlsrud, 2008; Farooq et al., 2021). It involves the voluntary integration of economic, environmental, social, and ethical concerns into a company's core business operations, decision-making processes, and interactions with stakeholders (Maignan & Ferrell, 2004). CSR reflects a company's recognition of its role in society and the acknowledgment of the broader impact of its actions beyond financial performance (European Commission, 2011). This paper aims to explore the historical perspective on CSR, with a focus on pre-1989 Slovakia cooperatives, and provide an overview of the current situation on the topic.

The historical perspective on CSR reveals that socially responsible activities have roots that predate the formalization of the CSR concept (Carroll, 1999; Visser, 2008; Velte, 2022). Scholars have traced the origins of CSR to the early 20th century, with the emergence of philanthropic activities by companies such as the Rockefeller Foundation and the Ford Foundation (Kilby, 2021). These activities were driven by a sense of moral obligation and a desire to address social issues. In the context of pre-1989 Slovakia, CSR practices were influenced by the political and economic environment of the time. The socialist regime emphasized collective or "shared" responsibility and the welfare of the society as a whole. Companies were expected to contribute to the development of the country and support social programs (Ericksen, 2014; Nollkaemper et al., 2020). In the contemporary business landscape,

CSR has become an integral aspect of corporate strategies and is widely recognized as a means of fostering sustainable development and positive stakeholder relationships (Maignan & Ferrell, 2004; Fatima & Elbanna, 2023). Companies are increasingly adopting formalized CSR practices, including sustainability reporting, stakeholder engagement, and adherence to international standards like ISO certifications (European Commission, 2011). These practices help companies demonstrate their commitment to responsible business conduct and enhance their reputation among stakeholders (Tanentzap et al., 2015). Additionally, CSR initiatives are seen as a way to mitigate risks, attract and retain talent, and gain a competitive advantage in the market. CSR has evolved from a philanthropic activity to a strategic business practice that is integrated into companies' core operations (Maignan & Ferrell, 2004; Pfister, 2020; Bharadwaj & Yameen, 2021). The historical perspective on CSR reveals that socially responsible activities have roots that predate the formalization of the CSR concept (Visser, 2008). In the current business landscape, CSR is widely recognized as a means of fostering sustainable development and positive stakeholder relationships. Formalized CSR practices, including sustainability reporting, stakeholder engagement, and adherence to international standards, have become standard components of responsible business conduct (European Commission, 2011; Maccarrone & Contri, 2021; Hsueh et al., 2023). The case of pre-1989 Slovakia provides a valuable context to explore historical CSR practices and understand the evolution of CSR in different socio-political contexts.

Contemporary economies grapple with long-term challenges such as climate change, severe depletion of natural resources, and adverse impacts on the global ecosystem. Outdated business models founded on the premise of inexhaustible resources have become untenable. Consequently, substantial emphasis is being placed on sustainable development and the transition to a circular economy. Making decisions that are adaptive and responsive to the dynamic business environment becomes imperative. Describing corporate sustainable development necessitates emphasizing three interconnected core concepts: economic growth, social equity, and the inherent resilience of natural systems to maintain dynamic equilibrium (Kislingerová, 2023). In 2011, the European Commission introduced a novel definition, characterizing corporate social responsibility as a company's obligation to consider the societal impact of its activities. CSR advances the notion that companies bear responsibilities extending beyond economic and legal obligations, encompassing obligations to society as a whole. It embodies the conduct of managers and employees that not only respects the economic and technical interests of the company but also serves the interests of all stakeholders (Tetřevová et al., 2017). The critical question revolves around the target audience for a company's social responsibility. To facilitate managerial decision-making regarding the focus of social responsibility efforts, Freeman proposed the stakeholder theory in 1984. Stakeholders, broadly defined as any group or individual capable of influencing or being affected by the organization's objectives, play a pivotal role in this paradigm (Freeman, 1984).

Nowadays, CSR is widely recognized as a means of fostering sustainable development and positive stakeholder relationships. Formalized CSR practices, including sustainability reporting, stakeholder engagement, and adherence to international standards, have become standard components of responsible business conduct. The case of pre-1989 Slovakia

provides a valuable context to explore historical CSR practices and understand the evolution of CSR in different socio-political contexts. The research gap in the existing literature pertains to the lack of comprehensive insights into CSR activities undertaken by businesses, particularly agricultural cooperatives, in the era preceding the political changes of 1989 in Slovakia. Despite the absence of an official CSR label, many organizations engaged in activities aligned with contemporary CSR principles. This gap inhibits a thorough understanding of how businesses pursued social, environmental, and economic responsibility before CSR became a widely recognized concept.

This paper seeks to fill the gap by providing a detailed exploration of the historical CSR practices of the agricultural cooperative JRD Krajné performed before 1989 in Slovakia. The study delves into the cooperative's diverse activities that may be considered socially responsible in today's context. By examining these pre-1989 CSR endeavors, this article aims to shed light on the organic development of socially responsible initiatives within the region's business culture. Through an analysis of the cooperative's social, environmental, and economic activities, this research contributes to a more comprehensive understanding of how businesses in Slovakia demonstrated a commitment to the well-being of their employees, local communities, and the environment before formal CSR practices were widely adopted. Additionally, this article highlights the importance of recognizing and preserving historical CSR practices as valuable precedents in shaping contemporary CSR strategies.

By bridging the research gap through a detailed investigation of JRD Krajné's pre-1989 CSR activities, this paper aims to offer valuable insights for businesses across various sectors, enabling them to learn from historical experiences and incorporate responsible practices into their current operations. Moreover, this research emphasizes the significance of implementing CSR not merely as a contemporary trend but as a time-honored approach to fostering sustainable business practices and contributing to the holistic development of society.

2. Methodology

The aim of this scientific study was to investigate the historical context of socially responsible activities implemented in Slovakia cooperatives before 1989. Specifically, we sought to explore the practices and initiatives conducted in the agro-sector business during the centrally planned economy era.

The methodology employed in this study involved the use of structured interviews as the primary data collection method. A predefined set of 11 open-ended questions was formulated to capture comprehensive insights into the subject matter. To ensure accuracy and clarity, the questions were translated for the interviewee, Ing. Vojtech Tĺčik, a recognized expert with extensive experience in the agro-sector business. Mr. Tĺčik served as the former chairman of the acclaimed Unified Agricultural Cooperative in Krajné during the centrally planned economy era in Slovakia before 1989. He also transitioned successfully into private entrepreneurship after 1989, leading several business sectors, with a focus on agro-sector activities. Therefore, we believe that he is a suitable subject for such research. The interview consisted of 11 open-ended questions:

- What CSR activities were conducted before 1989?
- Who managed and planned these activities?
- Were they centrally planned or monitored?
- How much funding was allocated to them?
- Were any awards granted that could be considered socially responsible today?
- Was there any certification of these activities?
- Were there any reports or documentation on these activities?
- Were responsible companies favored by customers, the state, and employees?
- Did multinational companies bring CSR to Slovakia after 1989?
- Do you believe CSR should be mandatory?
- Based on past experiences, what do you consider crucial for the current implementation of CSR activities in companies, not only in the agro-sector?

It is important to acknowledge certain limitations that may have influenced the outcomes of the study. Firstly, the sample size was limited to a single interviewee, which might not fully represent the diverse range of experiences and perspectives on the topic. Secondly, the study focused exclusively on socially responsible activities within the agro-sector, thus possibly omitting important insights from other sectors.

Due to the qualitative nature of the study and the restricted sample size, generalizability of the findings to the entire Slovakian pre-1989 context may be limited. It is necessary to exercise caution when applying these results to a broader population.

As the interviewee, Ing. Vojtech Tĺčik, has substantial expertise in agro-sector business, potential bias may exist in the responses provided. Efforts were made to minimize bias through impartially formulated questions and an objective approach to data analysis.

3. Results

Before 1989, the agricultural cooperative JRD Krajné, under the leadership of Ing. Vojtech Tĺčik, engaged in various activities that can now be considered as Corporate Social Responsibility (CSR) practices. These activities, although not officially labeled as CSR at that time, aimed to assist the cooperative's employees, the local community, and nature.

Social Activities: The cooperative focused on social activities that supported employees and their families. Notably, they provided a company-owned kindergarten, which facilitated working parents with young children, who were preferred in the society at the time. Additionally, JRD Krajné made above-average investments in workforce regeneration and offered a sauna and massage services to all employees. Moreover, the cooperative participated in international "družba", providing recreational opportunities abroad for its employees, even sending an entire plane of employees on vacation to Cuba. Obviously, the destinations were picked in regard of international partnerships of the entity and contemporary preferences, but regeneration of workforce regeneration and international cooperation were highly appreciated.

Environmental Activities: The cooperative's core focus was on ensuring the well-being of agricultural communities, making environmental activities a priority. They engaged in

activities such as soil protection, water management, land improvements, and habitat enhancements. Processes in agricultural primary production (both in plant and animal production) were aimed at achieving high yields, however, much attention was paid to activities nowadays labeled as "sustainability", for example: soil protection, biodiversity and water management. The extreme intensification of agriculture even in our territory took place mainly after 1989, while there is an effort to apply several of the agro-environmental principles from the period of peasant cooperatives to the present.

Economic Activities: JRD Krajné pursued economically oriented activities with the goal of achieving outstanding results compared to other entities within the region, country, and even whole Czechoslovakia. These activities were deeply rooted in a "social contract" ensuring that better overall performance by the cooperative would result in improved benefits for its members. The benefits were not limited to financial rewards but included additional distribution of surplus production or profits to employees in the form of naturals or supporting local infrastructure development, construction of public buildings, cemetery renovations, sidewalks, street lighting, and other public beneficial activities.

Planning and Management of CSR Activities: All activities, including those now considered socially responsible, were generally planned and conditioned by cooperation with supervisory bodies such as the Agricultural Production Administration, and the Slovak Union of Cooperative Farmers, etc. However, specific activities were directly overseen by the cooperative's presidency Officially, CSR activities were not centrally planned but were rather considered as part of other plans, if appeared separately, they were usually categorized as "representational" expenses. Therefore, no specific budget was allocated for CSR activities, but financial resources were available within the generous general budget for "representational activities". According to the former chairman, there were practically no limitations on funding, as good ideas were readily supported by the authorities who evaluated them on an individual basis. The financial resources for CSR activities not directly connected with the core activities of the entity many times came from the budget for "dožinky" or sponsorships from local communities, such as for football clubs or fire brigades.

Awards and Recognition: Awards were given to individual entities based on their economic performance and other indicators of engagement, including aspects that can be considered as CSR. Outstanding employees were also frequently rewarded with financial and non-financial incentives, and diplomas were presented to them with the participation of the whole community.

Certification and Reporting: Although there was no formal certification for these activities, the cooperative adhered to ISO systems and strict regulations regarding production and food processing, given its agricultural nature. Employees received various training on quality, and processes were closely monitored for correctness.

Perception and Support: The socially responsible businesses were greatly favored in the eyes of customers, the state, and employees. Entities that achieved not only good economic results but also demonstrated a commitment to societal well-being were positively perceived by various stakeholders. The employees were proud to work for such a company, and the local community strongly supported and collaborated with them. From the perspective of the state

and governing authorities, these companies were highly encouraged and seen as exemplary, enjoying special status and privileges among other businesses, both locally and internationally.

CSR Before and After 1989: Contrary to the notion that multinational companies introduced CSR to Slovakia after 1989, CSR activities were already prevalent before this period, albeit unofficially. In the agricultural sector, there existed a tradition of comprehensive approaches to benefiting all members of local communities, not just cooperative members. While these activities were not specifically named CSR and were not budgeted separately, the centrally planned system ensured monitoring and support for various aspects, including support for employees, communities, and nature.

Opinion on Mandatory CSR: The interviewee expressed a belief in the necessity of mandatory CSR. He stated that, the state should strongly support businesses in implementing CSR activities and establish a systematic approach for their realization.

Key Factors for Current CSR Implementation: According to interviewee, in contemporary CSR implementation for businesses, including those beyond the agricultural sector, collaboration among individuals, institutions, and local authorities in the region is crucial. Organizing events and platforms to facilitate knowledge sharing, cooperation, and coordination among stakeholders will lead to effective and efficient CSR practices. Additionally, focusing on concentrated production and supporting specialized areas with competitive advantages in the region can contribute to sustainable development. Establishing geographic clusters that unite local businesses, working communities, and nonprofit organizations can efficiently support CSR activities. The involvement of the state and local government authorities is vital in creating an environment conducive to the development of such regions, potentially providing assistance programs.

4. Discussion

The interview provides a valuable insight into the historical practice of corporate social responsibility of the JRD Krajné agricultural cooperative before the political changes in Slovakia in 1989. Although the cooperative was not officially designated as CSR, it engaged in activities that correspond to the current principles of CSR according to the triple bottom line (Elkington, 1997). These activities focused on social, environmental and economic aspects and demonstrated a commitment to employee care, community development and sustainable practices as they are currently perceived in a number of studies (Le et al., 2023; Vrabcová & Urbancová, 2023; Rostami & Salehi, 2024). The social activities of JRD Krajné were focused on the well-being of employees and their families. By providing a company nursery and offering facilities such as a sauna and massage services, the co-op has shown a genuine concern for work-life balance and the health of its employees.

The absence of central planning in the field of CSR suggests that these activities were driven primarily by local needs and values, rather than a standardized top-down approach. This grassroots involvement likely contributed to the success and relevance of the initiatives in their site-specific context. Study Tešovičová and Krchová (2022) demonstrates that today's companies continue to be more involved in regional environmental issues compared to global ones. Although the financial allocation for CSR activities was not allocated within the

dedicated budget, it came from resources allocated to "representational activities" or through sponsorship contributions from local communities. This points to the cooperative's ability to creatively raise funds for its socially responsible activities, often based on the merits of ideas and community support, Strečanský (2023) also came to similar conclusions in his study.

Contrary to popular belief, the respondent refutes the opinion that multinational companies introduced CSR practices in Slovakia after 1989. The situation before 1989 indicates that there were already efforts in society to carry out socially beneficial activities that corresponded with the spirit of that time (Benda, 2023).

The discussion concludes with the key factors that are decisive for the current implementation of CSR for businesses, even outside the agricultural sector. The emphasis on cooperation between individuals, institutions and local authorities in the region promotes knowledge sharing, collaboration and effective coordination of CSR practices. The creation of geographic clusters that connect businesses, communities and non-profit organizations creates a supportive ecosystem for CSR activities. The conclusions of our study correspond and appropriately extend the conclusions of the study carried out by Vrabcová and Urbancová (2023), when in their study carried out on a sample of 183 companies from the field of agriculture (n1 = 183) they identified factors influencing innovative areas in relation to sustainability. The results of the factor analysis showed a six-factor solution: process approach, social responsibility, quality management system, supply chain operational processes, production demand, and employee performance.

Overall, the interview sheds light on the historical CSR practices of the Slovak agricultural cooperative and provides valuable insights for the current and future implementation of CSR in various business sectors. The contribution of our study reflects the conclusions of Rostami & Salehi (2024), who emphasize that the agricultural sector and farmers' sustainability activities are considered critical factors for realizing a more sustainable future. In the light of past experiences, CSR is highlighted in our study as a necessary aspect of sustainable development and the need for active state support in creating a systematic framework for the implementation of CSR activities.

According to Le et al. (2023) corporate social responsibility has an impact and can induce managers to change their environmental strategies. Our study builds on these findings, and considering the fact that CSR continues to evolve, the historical perspectives presented in our study can guide business management and policy makers in promoting responsible practices and achieving sustainable development goals.

5. Conclusions

The literature review revealed that Corporate Social Responsibility (CSR) is a multifaceted concept encompassing ethical, socially responsible, and sustainable business practices. Although the formal CSR concept emerged later, historical evidence indicates that businesses, including agricultural cooperatives like JRD Krajné in pre-1989 Slovakia, engaged in activities aligned with contemporary CSR principles. These activities, centered around social welfare, environmental stewardship, and economic responsibility, reflected a commitment to employees, communities, and nature. While not officially labeled as CSR,

these practices provide valuable insights into the organic development of responsible business conduct in the region.

The current application of CSR principles in the management of agricultural enterprises operating within market mechanism conditions in many ways builds upon and continues the principles of social responsibility from the period before 1989. In the past, the economic performance and operational activity of PD Krajné were conditioned by bodies such as the Agricultural Production Administration, the Slovak Union of Cooperative Farmers, and others which to some extend set the rules and general expectations for the functioning of business entities as part of the community and society. Despite the changed business conditions after 1989 (market and price mechanisms), today the family company TBS, a.s. continues to invest in building a more comfortable countryside for the citizens of the region (supporting biodiversity, family-oriented management, waste minimization, preparation for droughts and floods, etc.).

This scientific study aimed to explore the historical CSR practices of JRD Krajné before 1989 in Slovakia. Structured interviews with Ing. Vojtech Tĺčik, the former chairman of the cooperative, provided comprehensive insights into socially responsible activities before 1989. Despite certain limitations, including restricted sample size and exclusive focus on the agro-sector, the study offers meaningful contributions to understanding pre-1989 CSR initiatives. Results of the interview highlighted various socially responsible activities undertaken by JRD Krajné. Socially, the cooperative supported its employees through facilities like a kindergarten, sauna, and massage services. Environmental initiatives focused on preserving agricultural communities through soil protection, water management, and habitat enhancements. Economically, the cooperative pursued excellence and shared benefits with members under the framework of a "social contract." The absence of central planning for CSR and creative funding strategies further illustrated the region's self-reliance in addressing societal needs.

The study of JRD Krajné's historical CSR practices before the political changes of 1989 in Slovakia offers several implications for contemporary business practices, particularly in how companies can integrate social responsibility into their operations for sustainable development:

- Wider integration of social activities into business operations - modern businesses can learn from their socially responsible activities by implementing employee support programs that go beyond the basic requirements to foster a positive workplace culture and enhance employee satisfaction and loyalty.
- Environmental stewardship as a core business strategy - the cooperative's environmental activities highlight the critical role of businesses in preserving natural resources. Today's companies can adopt similar environmental stewardship principles, integrating sustainable practices into their core operations to minimize their ecological footprint and contribute to the planet's health.
- Economic responsibility through community engagement - the concept of a "social contract" utilized by JRD Krajné, where better performance led to improved benefits for its members and the community, exemplifies the potential of businesses to drive societal progress.

Modern enterprises can engage in community development projects, support local infrastructure, and contribute to public well-being as part of their economic responsibility.

- Decentralized management of CSR activities - the decentralized management of CSR activities allowed JRD Krajné to address local needs effectively. This approach can be beneficial for contemporary businesses by enabling them to tailor their CSR initiatives to meet the specific needs of their communities, thereby enhancing the relevance and impact of their social responsibility efforts.

This research serves as a foundation for further investigations into historical CSR practices of various businesses and sectors in Slovakia. Expanding the sample size and including diverse perspectives will enhance the generalizability of findings. Additionally, exploring the impact of historical CSR activities on long-term sustainability and community development can provide deeper insights into the enduring benefits of responsible business practices. Future studies may also delve into the institutional and policy-level factors that facilitated socially responsible initiatives during the centrally planned economy era.

Conflict of interest: none.

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Foreign Trade of the Czech Republic: Are the Trading Partners Democracies or Authoritarian Regimes?

Martin KRÁL

University of Hradec Králové, Hradec Králové, Czech Republic; martin.kral.2@uhk.cz

Abstract: Today, many countries dependent on international trade are struggling. The COVID-19 pandemic has disrupted supply chains, delayed many shipments, and caused a significant economic downturn. As a result of other world events such as military conflicts, the imposition of economic sanctions, etc., many countries are reviewing their trading partners. This paper examines the foreign trade of the Czech Republic, specifically examining the position of exports and imports by democratic and non-democratic regimes. The analysis finds that the Czech Republic's export orientation differs from its import orientation. Approximately 93% of the value of the Czech Republic's exports goes to democratic countries. In contrast, the Czech Republic imports only 70% of the value of imports from these democratic countries. More than 26% of the Czech Republic's imports come from authoritarian regimes. However, these imports are not so easily substitutable – they are imports of raw materials (e.g. oil and natural gas) but also of consumer goods, the production of which is cheaper in authoritarian states. Given the Czech Republic's inland location and its anchorage in the center of Europe, this situation cannot be expected to change in future years.

Keywords: trade; export; import; democracy; development

JEL Classification: F14; F18

1. Introduction

The development of trade and globalization is a typical trend of the developed world in the 20th century and today. International trade is a key element of the global economy, linking nations and enabling the free flow of goods, services, and capital between different countries. This form of trade is not only about the exchange of physical products but also about the sharing of know-how, technology, and cultural influences. In today's world, where economies are increasingly interconnected, international trade is crucial to the growth and prosperity of nations (de Soyres & Gaillard, 2022). It provides opportunities for the development and diversification of economies, promotes innovation, and creates new jobs.

The importance of international trade cannot be overemphasized, as it allows countries to specialize in the production of those products and services in which they have a comparative advantage (Seyoum, 2007). This leads to more efficient production and use of resources, resulting in increased productivity and competitiveness. International trade also brings a diversity of products to the market, increasing consumer choice and encouraging innovation. With globalization and the increasing interconnectedness of the world's economies, international trade is becoming an integral part of the strategic planning of governments and companies, influencing economic, social, and political developments around the world.

For Western states, democratic values have become not only a fundamental pillar of domestic politics but also a key element in their international relations and business interactions. Western states emphasize democracy, the rule of law, human rights, and freedom as an integral part of their identity (Gabrielsson, 2022). These values are not only a rhetorical element but also function as filters in international trade (Yu, 2010). Western societies, including companies, often prefer trading partners that respect democratic norms and human rights. This may influence trade decisions because Western states tend to work with regimes that share their values and norms.

In some cases, the democratic values of Western states have led to restrictions on trade relations with authoritarian regimes. These countries may be subject to sanctions or restrictions on access to Western markets because they failed to respect human rights, lack democratic institutions, or violate the rule of law (Doornich & Raspotnik, 2020). These measures are intended to promote respect for democratic values and put pressure on authoritarian regimes to adopt democratic reforms. In this way, international trade becomes a tool to promote the spread of democratic values and contributes to shaping a global environment based on democracy, the rule of law, and human rights.

An example is the current state of trade between the West and the Russian Federation (Wang, 2015). As a result of the conflict in eastern Ukraine, most European countries have moved away from trade with the Russian Federation. A frequently cited argument is the failure to uphold democratic and Western values and the waging of war with another European country. It is often mentioned by Western politicians that, precisely because trade with Russia is being restricted, the flow of money from the West to Russia will also be restricted, and this will also reduce the Russian resources that are spent on financing war operations. The import of oil and gas from Russia, on which the countries of Eastern Europe in particular, but also Germany, were and still are dependent, is being replaced by these countries by importing these commodities from other countries. Examples include contracts from Norway, Qatar, Saudi Arabia and the United States (Kovanda, 2023). The Czech Republic is no exception to this. This article focuses on the orientation of Czech foreign trade, namely whether this trade is oriented towards countries that share the same democratic values as the Czech Republic.

2. Literature Review

Since its establishment in 1993, the Czech Republic has undergone significant developments in the sphere of foreign trade. After the fall of communism and the advent of a market economy, the Czech Republic gradually began to open its borders to international trade. At the beginning of the 21st century, the Czech Republic was integrated into the European Union, which has affected the dynamics of its foreign trade (Akhvlediani & Śledziewska, 2017). EU membership has allowed Czech firms easier access to the European market and has also provided support for the modernization and harmonization of trade practices with other Member States.

Over time, the Czech Republic has diversified its trading partners and is trying to expand its economic ties with different regions of the world. The Czech Republic's foreign trade has also been affected by global events such as economic crises, pandemics, or trade

conflicts, which have affected the country's trade flows and trade strategies (Chetverikova, 2021). At the same time, the Czech Republic has sought to promote innovation and modernization of its industry to maintain its international competitiveness while strengthening its role in the global trading environment.

In its foreign trade policy, the Czech Republic often faces a dilemma in which it must balance economic and democratic interests. Even though democratic values are a firm part of the Czech identity (Hanley, 2014), trade relations with some authoritarian regimes are not excluded; for example, the aforementioned trade with the Russian Federation, China, or Middle Eastern countries (Ministerstvo průmyslu a obchodu, 2024). We can therefore conclude that the Czech Republic engages in trade with various countries where democratic norms are not fully respected, due to the diversification of trading partners and economic interests.

This situation often raises discussions about the ethical aspects of foreign trade, where one has to consider the impact that economic cooperation can have on strengthening or weakening democratic processes in a given country. At the same time, however, the Czech Republic applies certain mechanisms and conditions to promote respect for fundamental human rights in its trade interactions with authoritarian regimes and, where appropriate, to create pressure for improved democratic standards in partner countries. These mechanisms are most often in the form of economic sanctions, but they also significantly affect Czech businesses (Hinčica et al., 2020).

The Czech Republic applies sanctions by the common European policy within the European Union. Sanctions are an instrument that enables the EU to respond to various international situations, such as human rights violations, threats to peace, or other forms of illegitimate behavior, particularly by third countries. The EU's common sanctions are designed to send a strong signal that can have an impact on a country's policy. This promotes respect for international standards and values that are key to the EU and its Member States. The application of sanctions thus creates an environment in which democratic values can be promoted while strengthening the EU's common security policy (Drapkin et al., 2022).

The imposition of trade sanctions can have consequences that include the need to seek alternative trading partners. When relations with certain countries are restricted or disrupted due to sanctions, the Czech Republic may turn to other regions or countries to diversify its trade portfolio. Finding new trading partners can be a strategic step to minimize the impact of sanctions on the domestic economy and maintain trade stability (Doornich & Raspotnik, 2020).

In this context, the Czech Republic can look for new opportunities in cooperation with economically dynamic regions and countries where sanctions are not applied. In this way, it can expand its trade links and minimize the risks associated with unilateral sanctions. At the same time, this diversification can contribute to strengthening the overall resilience of the Czech economy and move it towards a more sustainable business model. The search for new trading partners can thus be a strategic response to the challenges arising from international political and economic changes.

3. Methodology

This article deals with the issue of the Czech Republic's foreign trade in the current period, which is affected by dynamic global developments related to security, energy problems, and environmental challenges. The paper aims to analyze the Czech Republic's foreign trade and to answer the question of whether the Czech Republic is currently focused on trade with democratic states that uphold similar democratic values and principles, or whether, as a result of sanctions policy, it is merely "driving a wedge" – i.e. whether trade with some authoritarian regimes is being replaced by trade with other authoritarian states.

The data source for the analysis is the data available on the websites of official government institutions – the Ministry of Industry and Trade and the Czech Statistical Office of the Czech Republic. For international comparison, secondary data published by the European Statistical Office are used. Based on the data, the position of the Czech Republic is analyzed, both within the European Union as a whole and within the V4 countries. Subsequently, the foreign trade of the Czech Republic is examined - specifically in terms of exports and imports. Not only aggregated values (total volume of imports and exports) are analyzed, but also partial values, i.e. trade with the most important trading partners of the Czech Republic.

4. Results

4.1. European Trade Development

The development of European foreign trade has a rich history, dating back to the trade routes of medieval merchants and voyages of discovery. However, the key moments for the modern shape of European foreign trade were the founding steps of the European Community and later the European Union. Gradually, the single market was created, allowing the free movement of goods, services, capital and workers.

Another key milestone was the introduction of the euro in some EU countries, which facilitated trade and increased economic stability. The opening up of new markets in Central and Eastern Europe after the fall of the Iron Curtain brought another dimension to the growth of European foreign trade. Over time, the EU has become one of the biggest players in the world market.

In recent years, international trade within the European Union has developed very dynamically. The total volume of exports from 2011 to 2022 amounted to EUR 57 884.2 billion, while the volume of imports amounted to EUR 55 883.4 billion. Except 2022, the European Union's trade balance has been positive (an average of EUR 2 090.1 billion per year). Table 1 shows the values of exports and imports for the whole of the European Union over the period under review:

The largest economy in the European Union, and also the largest trading "power", is Germany, which accounted for 22.2% of total EU trade in 2022. The industrialized Germany is followed, perhaps somewhat surprisingly, by the Netherlands, given its geographic location and major trading crossroads. Other major trading economies include Italy, Belgium, France, Spain, Poland and the Czech Republic (see Figure 1).

Table 1. Evolution of EU exports and imports 2011-2022 (billion euro) (Eurostat, 2024)

Total EU	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Export	4,013.8	4,155.8	4,168.3	4,256.2	4,444.8	4,491.0	4,839.2	5,074.0	5,203.6	4,788.2	5,623.9	6,825.6
Import	3,997.5	4,027.3	3,961.5	4,026.2	4,156.1	4,177.2	4,569.1	4,870.9	4,952.4	4,510.4	5,510.2	7,124.5
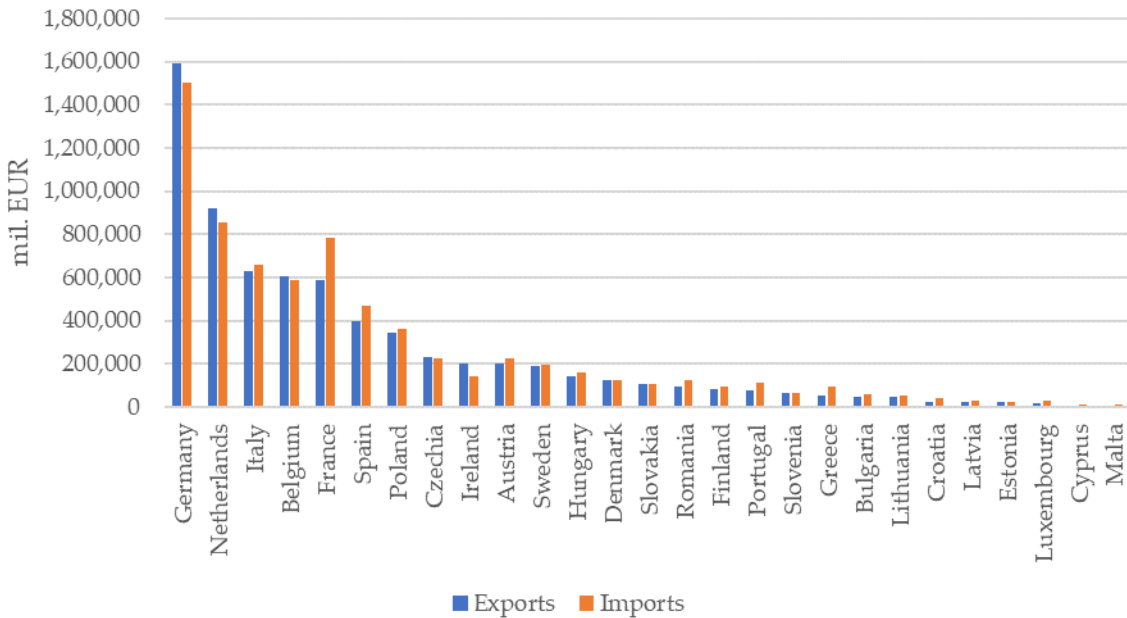
Figure 1. Exports and imports of EU countries in 2022 in million euro (Eurostat, 2024)

Malta, Cyprus, Luxembourg, and the Baltic States (Estonia, Latvia, and Lithuania) are at the other end of the list in terms of size (population, area). Thus, in general, it could be stated that the overall development and position of the European Union's international trade in goods is in the hands of a few major and mainly Western economies.

These Western economies also play a large part in determining the political direction of the European Union as a whole, while the smaller and less economically developed countries of Eastern Europe are essentially adopting this direction, although their trade has historically been oriented in a different direction – e.g. they are former satellites of the Eastern bloc (USSR) with very strong links to the current Russian Federation, for example in the supply of energy raw materials – oil and gas.

4.2. Trade Position of the Visegrad Countries

A group of Central European countries that are linked by a significant part of their history is the so-called Visegrad Group (V4). It consists of the Czech Republic, Poland, Slovakia and Hungary. These countries are known for their dynamic growth and transition to market economies after the collapse of the USSR. Joint efforts to transform their economies and institutional reforms have led to the modernization and opening of these countries to foreign investment and trade. In recent years, the V4 countries have become attractive destinations for investors in the automotive, manufacturing, and services sectors. Overall, the

V4 countries share strong historical and cultural ties, which strengthens them in their efforts to develop together and cooperate in various areas (Strnad, 2019).

The V4 countries account for about 10-12% of the EU's international trade (in 2022, this share was 11.99%). All these countries have also seen similar developments in international trade in recent years. The gradual growth in the volume of exported and imported goods is mainly due to the size of these countries (see Figure 2). Following the start of the COVID-19 pandemic, the volume of traded goods fell by an average of 4.25% but has been followed by significant growth since 2021 - e.g. the volume of exports increased by 14.30% in the case of the Czech Republic in 2021, 13.74% for Hungary, 16.25% for Slovakia and even 20.47% for Poland.
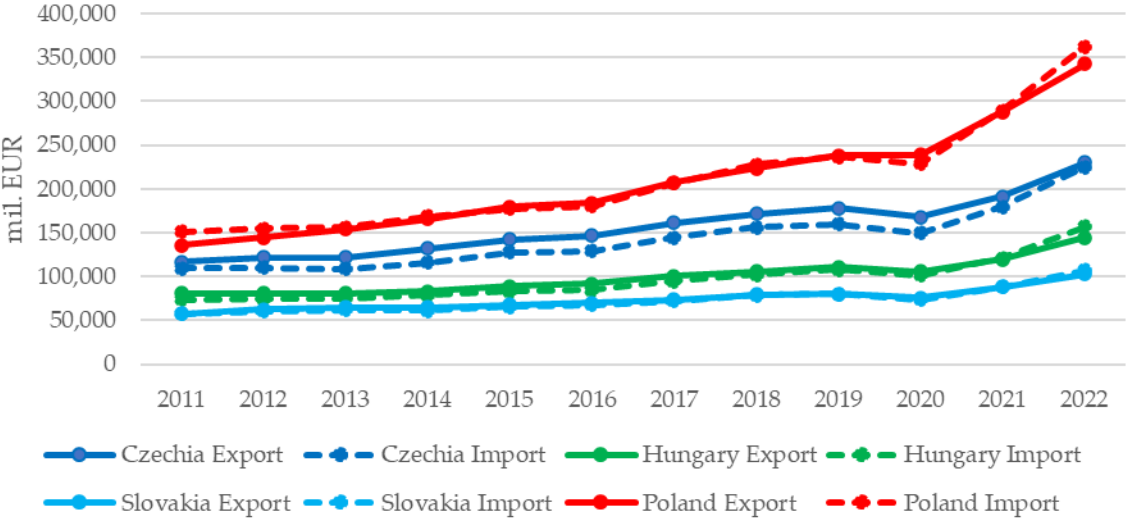
Figure 2. Development of foreign trade of V4 countries between 2011-2022 in million euro (Eurostat, 2024)

This dynamic growth continued in 2022, but rather than economic growth, the increase in the volume of foreign trade in these countries was due to rising prices (e.g. in the Czech Republic, the annual inflation rate was 15.1% in 2022). The increase in the volume of foreign trade therefore, at first sight, supports the idea of globalization and economic growth, but this growth is very strongly offset by the already mentioned higher prices.

4.3. Foreign Trade Orientation of the Czech Republic

One of the factors that is causing the rising price level is the sanctioning policies in some countries due to their own policies. An example of this is the extensive system of sanctions imposed after 2014 on the Russian Federation, which is, however, a leading importer of raw materials to the European Union countries and, above all, of labor to the V4 countries. In situations where economic sanctions are imposed, democratic countries often try to find alternative trading partners to minimize the impact of sanctions on their own economies. This includes finding new markets, expanding trade links with other countries, or promoting domestic production and innovation.

In seeking alternative trading partners, democratic countries may prefer to work with other democratic and human rights-respecting countries, thereby promoting the values they

consider important. These efforts can be part of broader efforts to promote democracy, human rights, and the rule of law internationally.

The Czech Republic's foreign trade has long been oriented within the European Union, exporting approximately 52.82% of its production for export to neighboring countries (Germany, Poland, Slovakia, Austria). Other important export patrons of the Czech Republic include France, Italy, the Netherlands and the United Kingdom. Imports to the Czech Republic are more differentiated also among countries outside the European Union. In addition to the V4 countries, Germany and other large European economies, imports from China and Russia are important for the Czech Republic. Both of these countries are authoritarian regimes according to the democracy index. The following Table 2 shows the top 20 trade partners of the Czech Republic:

Table 2. The most important foreign trade partners of the Czech Republic in 2022 (Czech Statistical Office, 2024; Economist Intelligence, 2023; Ministerstvo průmyslu a obchodu, 2024)

Country	Import mil. EUR	Export mil. EUR	Import share	Export share	Index of demo-cracy	Type of democracy
Germany	44.37	75.22	19.95%	32.87%	8.80	Full democracy
China	42.41	2.59	19.06%	1.13%	1.94	Authoritarian regime
Poland	17.93	16.27	8.06%	7.11%	7.04	Flawed democracy
Russian Federation	10.82	1.45	4.86%	0.63%	2.28	Authoritarian regime
Slovakia	9.36	19.17	4.21%	8.37%	7.07	Flawed democracy
Italy	8.57	9.37	3.85%	4.09%	7.69	Flawed democracy
Netherlands	6.18	8.31	2.78%	3.63%	9.00	Full democracy
France	6.12	10.57	2.75%	4.62%	8.07	Full democracy
Austria	6.01	10.23	2.70%	4.47%	8.20	Full democracy
USA	5.86	5.83	2.64%	2.55%	7.85	Flawed democracy
Hungary	5.15	7.82	2.32%	3.42%	6.64	Flawed democracy
South Korea	4.31	0.53	1.94%	0.23%	8.03	Full democracy
Japan	3.78	1.21	1.70%	0.53%	8.33	Full democracy
Spain	3.61	6.00	1.62%	2.62%	8.07	Full democracy
Belgium	3.53	5.04	1.59%	2.20%	7.64	Flawed democracy
United Kingdom	3.48	8.19	1.57%	3.58%	8.28	Full democracy
Romania	2.65	3.56	1.19%	1.55%	6.45	Flawed democracy
Turkiye	2.44	2.54	1.10%	1.11%	4.35	Hybrid regime
Vietnam	2.16	0.10	0.97%	0.05%	2.73	Authoritarian regime
Switzerland	2.03	3.32	0.91%	1.45%	9.14	Full democracy
Others	31.68	31.55	14.24%	13.79%		

Based on these data, it can be concluded that the main trading partners of the Czech Republic are mainly democratic countries. The Czech Republic's exports are mostly oriented to the countries of the European Union, and thus to countries with higher values of the democracy index. In terms of imports to the Czech Republic, however, the situation is

somewhat different. Total imports from democratic countries account for approximately 70%, but the other 26.39% are from countries with authoritarian governments (see Table 3). These are mainly the aforementioned Russia and China. Although the Russian Federation is the leading importer of oil, gas, and other essential raw materials (e.g. fertilizers) to the countries of Eastern Europe, despite the sanctions imposed, the tendency of these countries is not to restrict trade with this country at all.

Table 3. Trading partners of the Czech Republic in 2022 by level of democracy

Type of democracy	Share of import	Share of export
Full democracies	40.15%	59.09%
Flawed democracies	29.88%	34.37%
Authoritarian regimes	26.39%	3.41%
Hybrid regimes	3.38%	3.06%
No data available	0.21%	0.07%
Total	100.00%	100.00%

Another interesting fact is the fact that European countries, including the Czech Republic, are looking for alternative suppliers of gas and oil in the Middle East, e.g. in countries such as Qatar or Saudi Arabia. Both of these Arab countries, however, are also authoritarian states according to the democracy index, and the values of the democracy index for these countries are practically identical to those of Russia or China. So, the question here is whether the restrictions and sanctions against some states are really the result of the economic struggle of Western states to promote democracy and other related values, or whether these actions are motivated by other political ideas.

5. Discussion and Conclusion

To achieve positive economic development in the future, it is practically necessary to emphasize the development of international trade and to remove partial protectionist measures and barriers (Abboushi, 2010). As a result, it is then possible to concentrate production in countries and regions where it is more efficient, cheaper, or perhaps leads to higher value added. The allocation of factors of production in an efficient manner can then also lead to an increase in GDP and living standards of the population (Bashmakov, 2019).

Recently, the modern trend has been to subordinate economic decisions to political issues. Despite economic expediency, trade contacts with some countries whose political governance does not match that advocated or preferred by their trading partners are being curtailed (Gould-Davies, 2020). Examples include the Western world and its sanctions policies towards Asian countries in particular – e.g. China, Russia, and Middle Eastern countries. The cheap and technologically advanced production of Chinese products is becoming undesirable over time, as is the promotion of trade with the Russian Federation and the import of energy (Rühl, 2022) in Western countries, even though these imports are made using an already established distribution network that is much more environmentally friendly than, for example, the import of liquefied gas from the United States (Evropa v datech, 2024).

What is also striking is that the apparent trade orientation of these Western countries towards other democratic countries is not respected. This can be referred to as a 'double standard'. While some authoritarian countries are sanctioned and trade restriction tendencies are enforced, other authoritarian countries (e.g. Qatar, Saudi Arabia) are happily negotiated with by Western officials to increase trade (Export mag, 2024). Even though Czech foreign trade is export-oriented mainly to the democratic countries of the European Union, it would be advisable for positive economic development and growth to also focus on finding new trading partners. Given that in some cases there is trade with authoritarian regimes without any restrictions, it would be worth considering whether political views should be set aside and what is economically beneficial for each country should be promoted. Perhaps the political establishment would then save itself the trouble of finding other solutions - for example, how to combat the carbon emissions caused by the extremely un-eco-friendly shipping of 'green' liquefied gas across half the planet.

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Impact of Selected Macroeconomics Variables on Tourism Demand in the Czech Republic

Renáta KŘEČKOVÁ*, Daniela ŠÁLKOVÁ and Sergei YEKIMOV

Czech University of Life Sciences Prague, Prague, Czech Republic; kreckovar@pef.czu.cz; salkova@pef.czu.cz; yekimovs@pef.czu.cz

* Corresponding author: kreckovar@pef.czu.cz

Abstract: Article aims to provide an in-depth exploration of the key elements that contribute to shaping tourism demand, offering insights for practitioners, researchers, and policymakers. Tourism is a dynamic and multifaceted industry sensitive on changes. Forecast of demand in this part of tertiary sector is a key element for future. Investigation was directed to the impact of selected macroeconomic variables as the nominal exchange rate, inflation ratio, GDP per capita and renumeration of employees on tourism demand represented by number of overnights in hotels and similar accommodation. We used squared model based on Gauss-Markov theorem and our analysis encompasses a dataset covering Czech Republic, Slovakia, Germany, Austria, and Poland from 2000 to 2022. With the model we tried to evaluate the impact of inflation, renumeration of employees as well as nominal exchange rate on tourism in Czech Republic. Given the economic instability wage earnings and asset-based income are susceptible to fluctuations, consequently influencing individuals' purchasing power. The relationship between the exchange rate, inflation ratio, and tourism demand was recognized as significant whereby the statement took into the consideration share of wages and tourism industry on the GDP results.

Keywords: tourism; demand; tourists' arrivals; GDP; inflation; income

JEL Classification: L21; L26; M3

1. Introduction

Understanding tourism demand, the driving force behind the industry, is crucial for effective destination management, marketing strategies, and policy development. This scientific article delves into the intricate world of tourism demand by investigating the factors that influence consumer behavior and shape travel preferences. Drawing from established economic theories and empirical research, is presented a comprehensive analysis of the various dimensions of tourism demand, and shed light on the interplay between consumer attributes, external influences, and destination characteristics. Tourism demand encompasses the desire and ability of individuals to travel to different destinations for leisure, business, or other purposes. Black swan, as Covid-19 was, strengthen the need to predict future trends. Forecast of demand in this part of tertiary sector is a key element. The aim is to investigate the determinants of changes in Tourism demand in Czech Republic. The findings may contribute to further research endeavoring in several dimensions. Our focus is on exploring the macroeconomic determinants of tourism demand at a global level. The supply side was

not taken into consideration. Investigation is focused on three key factors: the nominal exchange rate, inflation ratio, GDP per capita as renumeration of employees per country. Evaluation of tourism demand has been based on two factors: the number of tourists, the number of overnights in hotels and similar accommodations. Our analysis encompasses a dataset covering Czech Republic, Slovakia, Germany, Austria, and Poland from 2000 to 2022. Usage of these data will lead us to conclusions about the importance of these macroeconomic variables as key factors of tourism demand.

2. Theoretical Background

Central to understanding tourism demand is the application of consumer theory, which considers how consumers make choices based on utility maximization, basically how consumer preferences, income levels, prices of goods and services, and related factors influence the decision to embark on a travel experience. Alfred Marshall in fundamental theory of microeconomics refers to the interplay between the quantity of goods or services that producers are willing to offer (supply) and the quantity that consumers are willing to purchase (demand). Marshall's scissors highlight the complex relationship between relative prices and income distribution, emphasizing that changes in prices can have varying effects on different factors of production, leading to shifts in the distribution of income within an economy. The Marshallian demand function provides a solution to the problem of maximizing consumer utility given a specific income and prices. It is also known as the uncompensated demand function because it does not involve compensating the consumer for changes in real income when prices rise, unlike the Hicksian demand function. Marshall's theory capitalizes on the idea that the demand curve reflects an individual's diminishing marginal value of a good. According to this theory, a consumer's purchasing decision hinges on the utility gained from a good or service in relation to its price. The reservation price represents the maximum price a buyer is willing to pay (WTP) or the minimum price a seller is willing to accept (WTA) for a particular good or service in the marketplace. These values reflect the potential prices at which buyers and seller age in transactions (Inoua & Smith, 2022). On macroeconomic level through perspective of Keynesian economy it has been introduced the fact that demand creates its own supply hence changes in aggregate demand cause changes in real GDP and employment.

2.1. Development Stage of the Country

Modelling of supply and demand is dependent partially on development stage of country. The measuring the relationship and correlation between tourism and country development is matter of many studies. During the period spanning the late 19th century to the mid-20th century, Modernization Theory (MT) arose as a prominent popular developmental paradigm that garnered significant attention. It is often perceived as an outgrowth of another theoretical framework known as growth theory, firmly rooted in the principles of Keynesian economics (Friedmann, 1997). Modernists framed four main theories of development and described factors influencing demand and supply: modernization, dependency, world-systems, and globalization (Reyes, 2019). Dependency theory as response on Modernization Theory,

formulated premise that, historically disadvantaged nations have been systematically denied development opportunities by wealthier and more developed countries (Willis, 2020). The theory of neoliberalism based on noneconomic and fiscal barriers became very relevant and its core principle advocates for the unrestricted movement of capital and global trade. According to neoliberal development and general modernization theories, the standard of living is measured by economic growth (Manzoor et al., 2019). Sustainable theories are going beyond economic factors and take into the consideration sustainable approach of all parties of economy. This study will concentrate on the economic determinants influencing tourism demand and its correlation with chosen macroeconomic variables.

2.2. Economic Cycle

The concept of tourism demand is based on the classic definition of demand in the economy. The specificity of tourism represents a specific product or service – in this case, we are talking about the so-called tourism product, which represents a group of mutually complementary goods and services (Song et al., 2023). Business entities in tourism make decisions about public procurement, investment, and employment based on the expected values of future demand as well as the expected consequences in the demand for tourism determinants (Jeřábek, 2019). Tourism demand is influenced by the economic cycle period and the concept of rational expectations. While major business cycle fluctuations strongly influence consumer demand for goods and services, such as in times of economic recession and boom, the response of tourism demand is not necessarily immediate and straightforward because of substitution effects between types of destinations and lags between decision making and the actual holiday (Guizzardi & Mazzocchi, 2010). An increase in tourism flow and demand can bring positive economic outcomes to the nations, especially in GDP and employment opportunities (Manzoor et al., 2019). According to data from the World Tourism Organization (UNWTO), the development of international tourism was significantly affected by the manifestations of the economic crisis in 2008. The year saw a notable slowdown in the year-on-year growth of visitor arrivals, dropping to 1.8% from 6.9% in 2007. This deceleration continued into 2009. These declines are more pronounced in the European region, as well as in Central and Eastern Europe. The implementation of lockdown measures has interrupted travel opportunities and production chains, leading to a shortage in the availability of goods and services. This disruption has coincided with individuals enduring periods of non-employment, and companies grappling with non-productive phases, resulting in a disjunction between the demand and supply dynamics resulting to a situation where demand exceeds the supply. Prior to the Covid-19 pandemic, the growth rate of the global Travel & Tourism sector outpaced the growth of the global economy for nine consecutive years. After a 50.4% fall in the contribution of the sector to the global economy, Travel & Tourism recovered by 21.7% in 2021 – Figure 1. In comparison, the global economy bounced back by 6.7%. Travel & Tourism's pace of recovery was slowed down by the spread of the Omicron variant in the second half of 2021, this forced governments to reinstate restrictions on international travel (WTTC). The impact in tourism demand of Czech Republic measured in tourists' overnights is aligned with global changes - shown in Figure 2. Length of the stay is one of the parameters which is correlating with trend weekly – Figure 3.
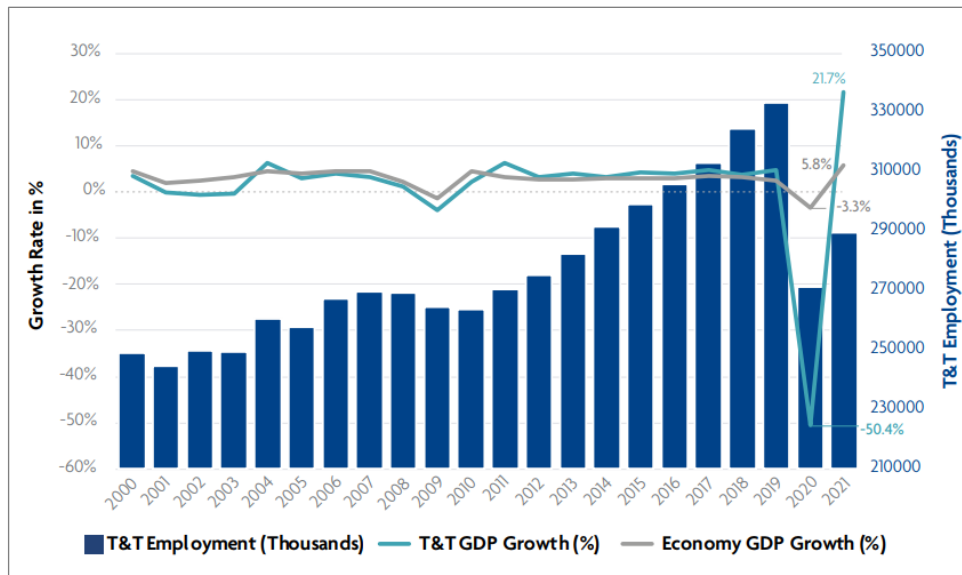
Figure 1. World Economic Impact Timeline, 2000–2021 (WTTC, 2022)
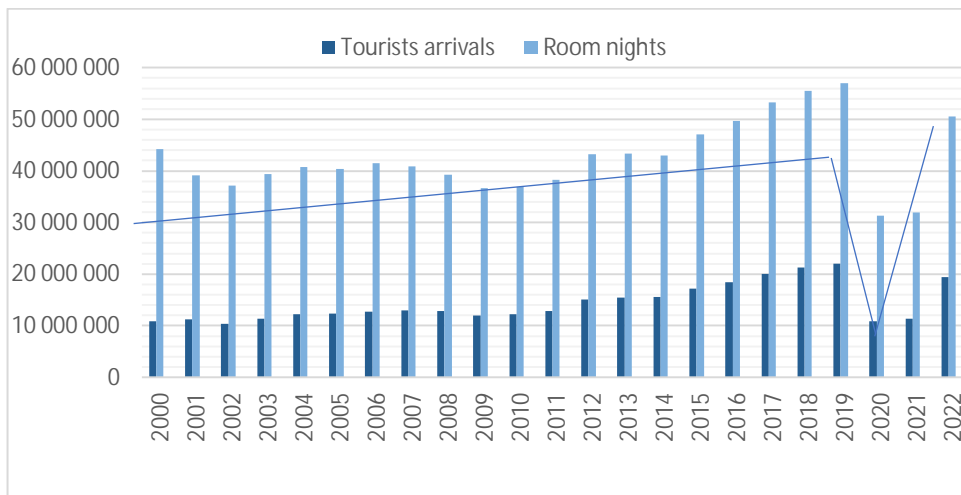
Figure 2. Arrivals and nights spent at tourist accommodation establishments Czech Republic, 2000–2022 (Eurostat, 2023b, 2023c)
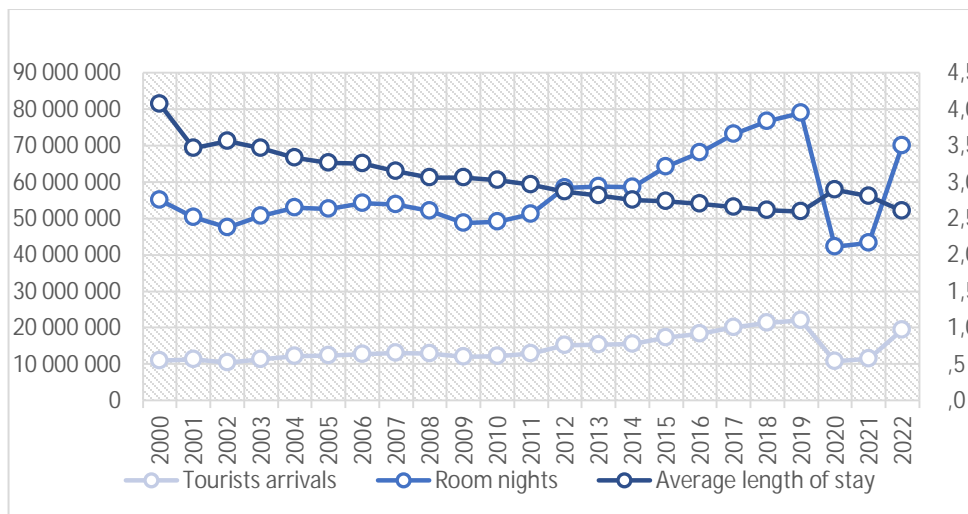
Figure 3. Average length of stay at tourist accommodation establishments in the Czech Republic, 2000–2022 (Eurostat, 2023c)

The pursuit of generating tourism demand stands as a primary goal for destinations aiming to attract visitors and maximize the advantages offered by the tourism industry. The challenge lies in understanding how to generate tourism demand (Song et al., 2023). In past studies has been proposed four criteria that can be utilized for this purpose. These criteria include: the number of arrivals; the monetary aspect, such as the amount of travel expenditure; the temporal aspect, such as the duration of stay in the destination: and the distance to the destination, which refers to the distance travelled in kilometers (Jeřábek, 2019). Factors such as technological advancements, geopolitical shifts, and environmental concerns might be potential drivers of change. Tourism spending is significantly dependent on the disposable income available to households and consequently disposal income is influenced by level of taxes and inflation ratio in the source country. There are four distinct hypotheses concerning the relationship between tourism and economic growth. Firstly, the tourism-led growth hypothesis (TLGH or TLEG) asserts that tourism plays a pivotal role in driving economic expansion. Conversely, the growth-led tourism hypothesis (GLTH or EDTG) posits that economic growth contributes to the advancement of the tourism sector. The third perspective suggests a bidirectional link between the two (bidirectional causality hypothesis – BC), while the fourth viewpoint adopts a neutral stance (no causality hypothesis – NC) (Badulescu et al., 2020).

3. Aim of the Research

The tourism sector is under the sway of two primary categories of influences: rational and irrational factors. For the scope of this research, we will intentionally omit the examination of psychological elements like trends, perception, and the sense of safety associated with the destination in question. In the literature, there are at least two classes of tourism models, those explaining the distribution of outward flows from a single source market - outbound modelling and those explaining aggregate tourism flows into a single destination - inbound modelling. (Zhou et al., 2007). The ambition of this paper is to investigate the effects that the real exchange rate, inflation ratio, GDP per capita as renumeration of employees per country have on inbound tourism demand (number of tourist and their overnights) from Germany, Austria, Poland, and Slovakia to Czech Republic over the period 2000–2022 measured in number of arrivals and overnights in hotels and similar accommodation establishments. We examine the relationship between growth of tourism demand represented by two factors: the number of tourists and overnights in hotels and similar accommodations and macroeconomic variables: the real exchange rate, inflation ratio, GDP per capita as renumeration of employees per country.

4. Data Collection and Methodology

4.1. Data Collection

To study the impact of chosen macroeconomic variables on growth of tourism demand in Czech Republic, the annual time series data from 2000 to 2022 was taken for analysis. In this study, the real exchange rate, inflation ratio, GDP per capita as renumeration of

employees per country were taken as an independent variable and the annual growth of tourism demand represented by the number of arrivals/overnights in hotels and similar accommodations were used as dependent variables. For data collection, different sources were used, i.e., Czech Statistical Office, Eurostat, MMR, World Travel and Tourism Council, and Tourism Economic Impact annual reports and used were data provided by The World Bank database. Given the limited availability and accessibility of the data, this study refers to the period 2000–2022. The data in Figure 4. - Number of guests in collective accommodation establishments by country in the Czech Republic, 2000–2022, (CZSO, 2023b), specific to various tourist-originating countries, reveals the quantity of tourists arriving from different nations and their subsequent accommodation over the period spanning 2000 to 2022. The data shows surge of visitors to Czech Republic originating from Slovakia, Poland, Germany, and Austria. Figure 5. describes Number of overnight stays in collective accommodation establishments by country in the Czech Republic, 2000–2022, (CZSO, 2023a) and provides a graphical representation of the evolution of tourist overnights by the nationalities mentioned earlier, tracing the timeline from 2000 to 2022. These figures show characteristic seasonal fluctuations commonly associated with patterns of tourism demand. During the crisis periods, there's a noticeable drop in tourist numbers, whereas a subsequent increase in visitor arrivals is evident in the post-crisis phases, commencing the year 2009 and 2022. Considering explanatory factors, the research includes considerations of income (measured by GDP per capita) and price-related variables (inflation rate specific to each country). While the income factor typically relies on quarterly GDP data, to maintain consistency in the analysis, the study opts for the Industrial Production Index (IPI) as a proxy for GDP (Jeřábek, 2019). In the context of this study, the IPI is utilized in its fundamental index form (Base 2015 = 100). Contrary to its name, the industrial production index doesn't aim to quantify production itself; rather, it theoretically mirrors the progress of value addition across various industrial sectors. To achieve this, the contributions received by one sector from another need to be subtracted from its overall output. This approach prevents duplicative counting of production, ensuring that the level of vertical integration among sectors doesn't sway the outcomes of the indicator. The price dimension of tourism is gauged using the real exchange rate (RER). This rate is defined as the ratio between the price level abroad Czech Republic and the domestic price level, wherein the foreign price level is converted into domestic currency units using the prevailing nominal exchange rate. For purpose of this study was used the Harmonised Index of Consumer Prices (HICP) as inflation indicator. This statistical estimate is subject to sampling errors because it is based on a sample of consumer prices and household expenditure, only. HICP is a set of consumer price indices (CPIs) calculated according to a harmonized approach.

4.2. Methodology

In this study, we study the impact of domestic inflation in the Czech Republic, Austria, Germany, Poland and Slovakia on the tourist activity of residents of these countries and tourists flow from these countries to the Czech Republic. The model is set to study hypothesis:
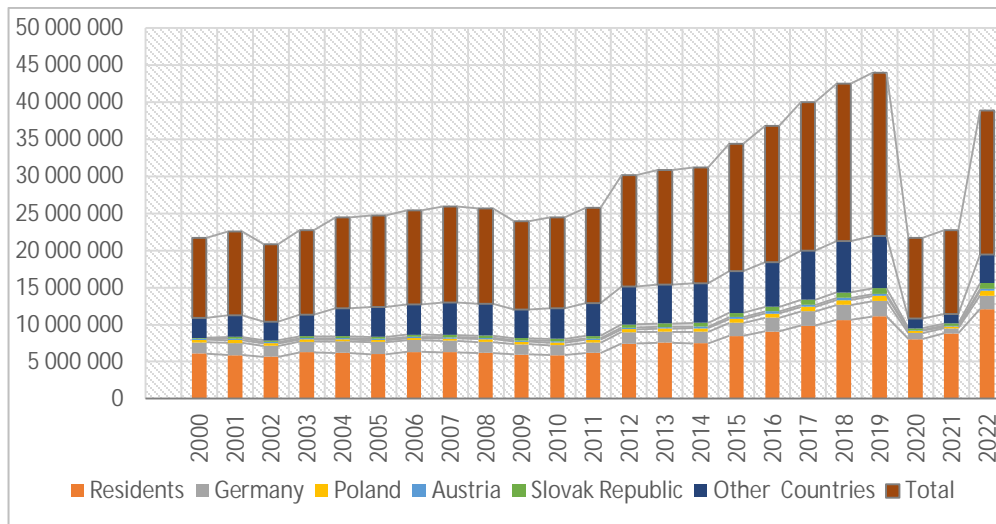
Figure 4. Number of guests in collective accommodation establishments by country in the Czech Republic, 2000–2022 (CZSO, 2023b)
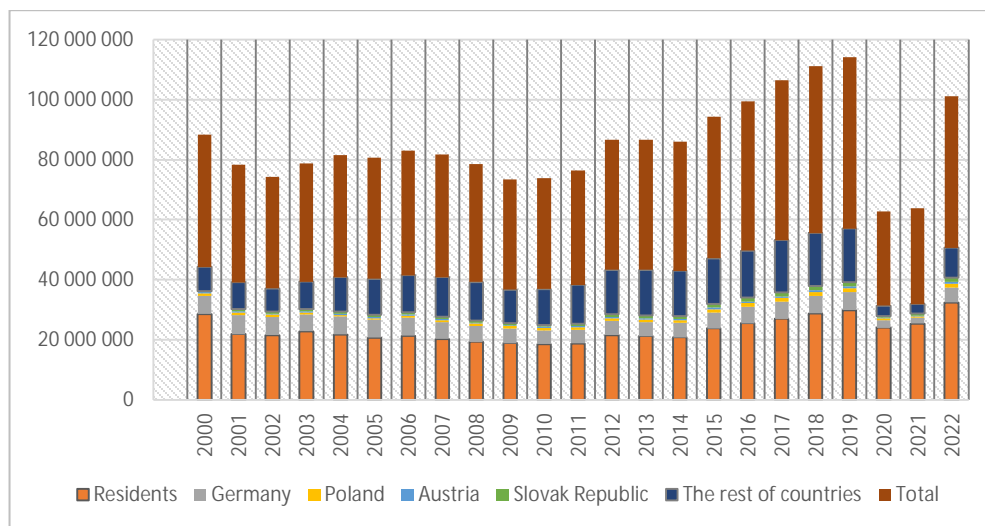
Figure 5. Number of overnight stays in collective accommodation establishments by country in the Czech Republic, 2000–2022 (CZSO, 2023a)

Hypothesis 1 (H1): There is a positive association between annual tourism demand and GDP/IPI. The higher disponible income has positive influence on tourism demand represented by number of tourists and their overnights.

Hypothesis 2 (H2): There is a negative association between annual tourism demand and inflation ratio. Higher inflation in destination negatively influences tourism demand at all, including residents.

According to the Gauss-Markov theorem, the use of the least squares method is advisable if the following conditions are met:

1. Data model X_i has the correct specification
2. $\forall\ X_i$ they are not equal to each other and are deterministic
3. All errors have the same variance equal to σ^2
4. All errors are not systematic $E(\varepsilon_i) = 0, \forall i$
5. Errors do not correlate with each other $Cov(\varepsilon_i, \varepsilon_j) = 0, \forall\ i, j$

There is no proof that conditions 3, 4, 5 are met for our problem, we will not use a regression model of the type in our calculations: $Y_i = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \cdots + \beta_n * X_n$

(1) In case of functional dependency $y = f(x)$, then ε elasticity is a quotient of the division of the relative change in function $f(x)$, on the relative change of the argument x: $\varepsilon = \frac{\Delta y}{y} : \frac{\Delta x}{x} = \frac{\Delta y}{\Delta x} * \frac{x}{y} = \frac{dy}{dx} * \frac{x}{y} = \frac{dln(y)}{dln(x)}$

(2) We used formula for finding the derivative of a parametric function, in our case, we can take time as a parameter: $\frac{dy}{dx} = \frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{\dot{y}}{\dot{x}}$

(3) Where the dot above the variable means the time derivative. Considering (3) and (2), we can write: $\varepsilon = \frac{\frac{dln(y)}{dt}}{\frac{dln(x)}{dt}}$

(4) Initial data for calculations number of guests in Czech hotels in 2000-2022 NOG (CZSO, 2023b), Harmonized Index of Consumer Prices on 2000-2022 HICP (Eurostat, 2023a), Industrial Production Index (IPI) on 2000-2022 (Eurostat, 2023d) were used. Number of guests (NOG) characterizes the activity of tourists, HICP characterizes the rate of inflation, IPI characterizes the activity of the economy in 2020-2022.

Numerical series characterizing the natural logarithm of the number of guests in Czech hotels in 2000-2022 (NOG) in Table 1, natural logarithm Harmonized Index of Consumer Prices (HICP) in 2000-2022 in Table 2 and Industrial Production Index (IPI) in 2000-2022 in Table 3 interpolate using Fermi-Torricelli points (Yekimov, 2021).

Table 1. Natural logarithm of the number of guests in Czech hotels in 2000-2022 (NOG), Ln(NOG)

Year	Czech Republic	Germany	Austria	Poland	Slovakia
2000	62.4833	82.5	70.35	47.6167	40.5917
2001	66.6667	82.75	72.7583	47.9167	41.9667
2002	68	81.85	73.2417	48.7083	44.925
2003	70.5	82.275	74.7583	52.7917	51.8833
2004	77.075	84.775	79.25	59.2333	53.7583
2005	79.5167	87.6583	82.6167	62.1917	53.4333
2006	85.95	92.7	88.9167	69.8917	61.7667
2007	94.475	98.3167	94.2083	76.5	71.9917
2008	92.075	98.3333	95.5917	78.1583	82.8667
2009	80.1833	82.2417	84.6917	74.925	71.5333
2010	86.9333	91.1667	90.2417	83.2667	80.1167
2011	91.9333	97.8	96.3583	89.325	85.3333
2012	91.1167	97.4833	96.55	90.3667	88.1
2013	91.15	97.6083	97.0167	92.75	89.4583
2014	95.8	98.9167	97.9833	95.75	92.425
2015	100.15	99.75	100.0083	99.9917	99.9833
2016	103.1583	100.575	102.15	103.1583	103.4917
2017	110.1083	103.7167	108.0333	110.25	108.1333
2018	113.525	104.75	113.375	116.6333	114.3
2019	113.1	101.2833	113.4083	121.6417	115.15
2020	105.25	91.5917	106.75	119.0667	105.2583
2021	111.7667	95.825	118.575	136.6917	115.9833
2022	114.8	95.4917	126.9583	151.7333	111.5333

Table 2. Natural logarithm harmonized Index of Consumer Prices (HICP) on 2000-2022, Ln (HICP)

Year	Czech Republic	Germany	Austria	Poland	Slovakia
2000	4.3012458	4.37	4.3177436	4.25	4.1190914
2001	4.3455355	4.39	4.3404774	4.30	4.1881764
2002	4.3598023	4.40	4.3571574	4.32	4.2226034
2003	4.3590565	4.41	4.3700911	4.33	4.3035695
2004	4.3846274	4.43	4.3895503	4.36	4.3756417
2005	4.4001939	4.45	4.4103610	4.38	4.4031458
2006	4.4209468	4.47	4.4270896	4.40	4.4449036
2007	4.4498800	4.49	4.4488574	4.42	4.4636258
2008	4.5107679	4.52	4.4805985	4.46	4.5022327
2009	4.5167032	4.52	4.4846114	4.50	4.5114454
2010	4.5286490	4.53	4.5014102	4.53	4.5183679
2011	4.5500098	4.55	4.5363023	4.57	4.5583668
2012	4.5847123	4.57	4.5616971	4.60	4.5951030
2013	4.5985651	4.59	4.5826519	4.61	4.6096352
2014	4.6026671	4.60	4.5971548	4.61	4.6086142
2015	4.6052535	4.61	4.6051702	4.61	4.6051702
2016	4.6117319	4.61	4.6148317	4.60	4.6003419
2017	4.6356994	4.63	4.6368949	4.62	4.6141547
2018	4.6550708	4.64	4.6578733	4.63	4.6391690
2019	4.6805868	4.66	4.6726731	4.65	4.6665083
2020	4.7128281	4.66	4.6864583	4.69	4.6864506
2021	4.7453668	4.69	4.7136733	4.74	4.7142563
2022	4.8835592	4.78	4.7963414	4.86	4.8287137

Table 3. Natural logarithm Industrial Production Index (IPI) on 2000-2022, Ln(IPI)

Year	Czech Republic	Germany	Austria	Poland	Slovakia
2000	4.3012458	4.37	4.3177436	4.25	4.1190914
2001	4.3455355	4.39	4.3404774	4.3	4.1881764
2002	4.3598023	4.40	4.3571574	4.32	4.2226034
2003	4.3590565	4.41	4.3700911	4.33	4.3035695
2004	4.3846274	4.43	4.3895503	4.36	4.3756417
2005	4.4001939	4.45	4.410361	4.38	4.4031458
2006	4.4209468	4.47	4.4270896	4.40	4.4449036
2007	4.4498800	4.49	4.4488574	4.42	4.4636258
2008	4.5107679	4.52	4.4805985	4.46	4.5022327
2009	4.5167032	4.52	4.4846114	4.50	4.5114454
2010	4.5286490	4.53	4.5014102	4.53	4.5183679
2011	4.5500098	4.55	4.5363023	4.57	4.5583668
2012	4.5847123	4.57	4.5616971	4.60	4.5951030
2013	4.5985651	4.59	4.5826519	4.61	4.6096352
2014	4.6026671	4.60	4.5971548	4.61	4.6086142
2015	4.6052535	4.61	4.6051702	4.61	4.6051702
2016	4.6117319	4.61	4.6148317	4.60	4.6003419
2017	4.6356994	4.63	4.6368949	4.62	4.6141547
2018	4.6550708	4.64	4.6578733	4.63	4.6391690
2019	4.6805868	4.66	4.6726731	4.65	4.6665083
2020	4.7128281	4.66	4.6864583	4.69	4.6864506
2021	4.7453668	4.69	4.7136733	4.74	4.7142563
2022	4.8835592	4.78	4.7963414	4.86	4.8287137

The possibility of interpolation of numerical series by series of exponents was proved (Leontiev, 2017). This was implemented using the example of the numerical series of Hungary's GDP for 1992-2002 (Yekimov, 2022).

Functions are differentiated by time. Using formulas below the elasticity coefficients were determined:

$$\varepsilon_{NOG_{CZ};IPI_{CZ}}=\frac{d/dt\,(CZ\_NOG\_LN)}{d/dt\,(CZ\_IPI\_LN)} \quad \text{and} \quad \varepsilon_{NOG_{CZ};HICP_{CZ}}=\frac{d/dt\,(CZ\_NOG\_LN)}{d/dt\,(CZ\_HICP\_LN)}$$

$$\varepsilon_{NOG_{SK};IPI_{SK}}=\frac{d/dt\,(SK\_NOG\_LN)}{d/dt\,(SK\_IPI\_LN)} \quad \text{and} \quad \varepsilon_{NOG_{SK};HICP_{SK}}=\frac{d/dt\,(SK\_NOG\_LN)}{d/dt\,(SK\_HICP\_LN)}$$

$$\varepsilon_{NOG_{PL};IPI_{PL}}=\frac{d/dt\,(PL\_NOG\_LN)}{d/dt\,(PL\_IPI\_LN)} \quad \text{and} \quad \varepsilon_{NOG_{PL};HICP_{PL}}=\frac{d/dt\,(PL\_NOG\_LN)}{d/dt\,(PL\_HICP\_LN)}$$

$$\varepsilon_{NOG_{DE};IPI_{DE}}=\frac{d/dt\,(DE\_NOG\_LN)}{d/dt\,(DE\_IPI\_LN)} \quad \text{and} \quad \varepsilon_{NOG_{DE};HICP_{DE}}=\frac{d/dt\,(DE\_NOG\_LN)}{d/dt\,(DE\_HICP\_LN)}$$

$$\varepsilon_{NOG_{AT};IPI_{AT}}=\frac{d/dt\,(AT\_NOG\_LN)}{d/dt\,(AT\_IPI\_LN)} \quad \text{and} \quad \varepsilon_{NOG_{AT};HICP_{AT}}=\frac{d/dt\,(AT\_NOG\_LN)}{d/dt\,(AT\_HICP\_LN)}$$

5. Results

The results of the calculations are shown in the Figures 1., 2., 3., 4., 5.

- Elasticity coefficients $d_{NOG_{CZ}}/d_{HICP_{CZ}}$, $d_{NOG_{CZ}}/d_{IPI_{CZ}}$, $d_{NOG_{DE}}/d_{HICP_{DE}}$, $d_{NOG_{DE}}/d_{IPI_{DE}}$, $d_{NOG_{AT}}/d_{HICP_{AT}}$, $d_{NOG_{AT}}/d_{IPI_{AT}}$, $d_{NOG_{PL}}/d_{HICP_{PL}}$, $d_{NOG_{PL}}/d_{IPI_{PL}}$, $d_{NOG_{SK}}/d_{HICP_{SK}}$, $\frac{d_{NOG_{SK}}}{d_{IPI_{SK}}}$ are not constant values, but fluctuate relative to the line $\varepsilon=0$

- Elasticity coefficients $d_{NOG_{CZ}}/d_{HICP_{CZ}}$, $d_{NOG_{CZ}}/d_{IPI_{CZ}}$, $d_{NOG_{PL}}/d_{HICP_{PL}}$, $d_{NOG_{PL}}/d_{IPI_{PL}}$, $d_{NOG_{SK}}/d_{HICP_{SK}}$, $d_{NOG_{SK}}/d_{IPI_{SK}}$ they fluctuate in different directions.

- Elasticity coefficients $d_{NOG_{DE}}/d_{HICP_{DE}}$, $d_{NOG_{DE}}/d_{IPI_{DE}}$, $d_{NOG_{AT}}/d_{HICP_{AT}}$, $d_{NOG_{AT}}/d_{IPI_{AT}}$ they fluctuate unidirectionally.
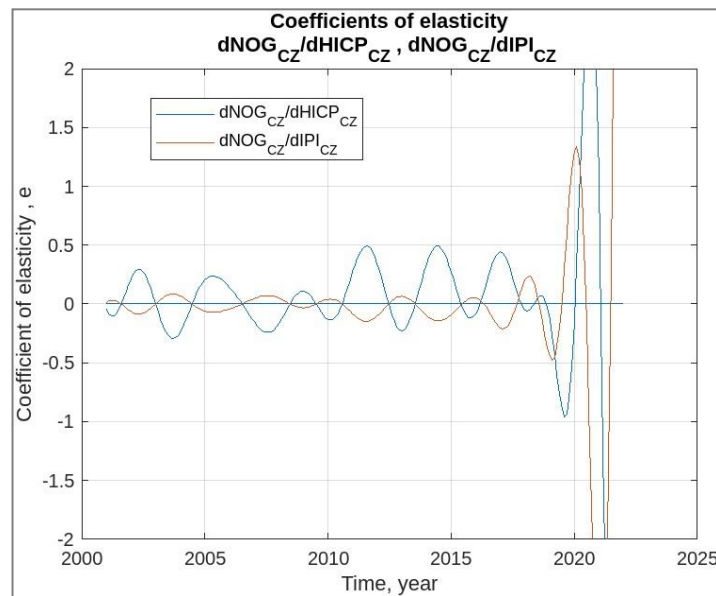
Figure 6. Coefficients of elasticity $d_{NOG_{CZ}}/d_{HICP_{CZ}}$, $d_{NOG_{CZ}}/d_{IPI_{CZ}}$
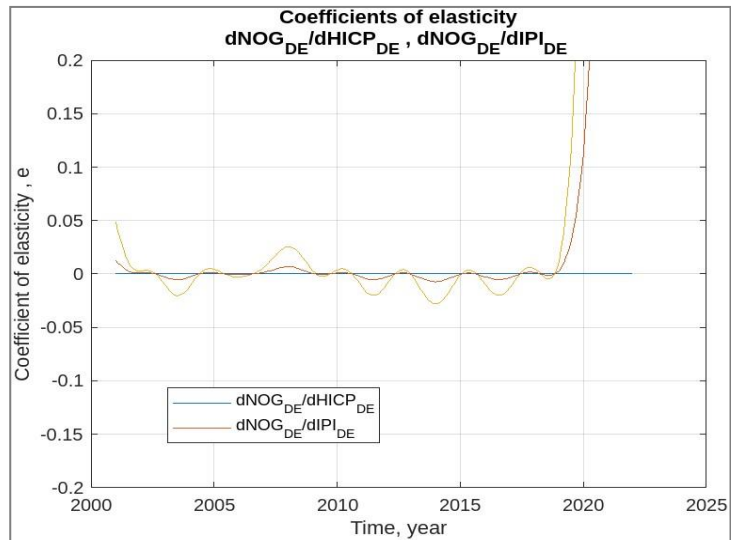
Figure 7. Coefficients of elasticity $d_{NOG_{DE}} / d_{HICP_{DE}}$, $d_{NOG_{DE}} / d_{IPI_{DE}}$
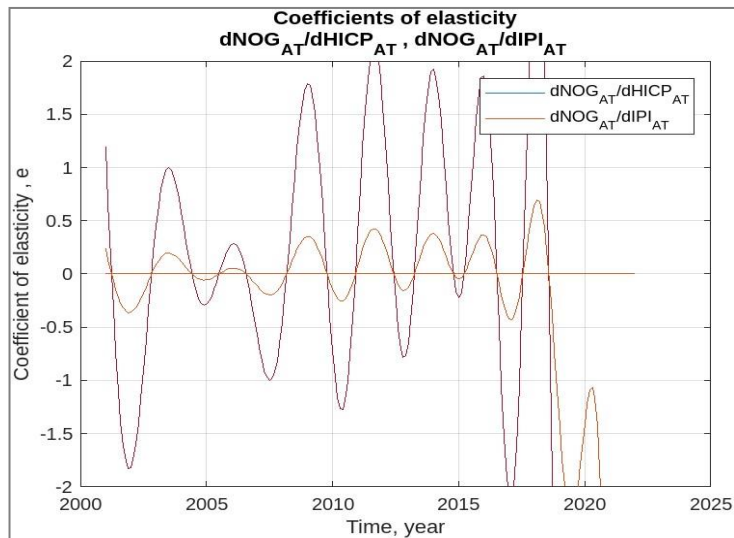
Figure 8. Coefficients of elasticity $d_{NOG_{AT}} / d_{HICP_{AT}}$, $d_{NOG_{AT}} / d_{IPI_{AT}}$
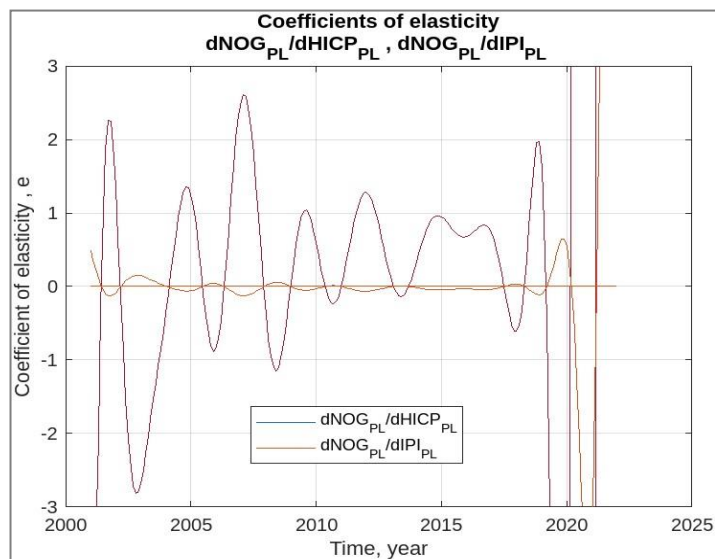
Figure 9. Coefficients of elasticity $d_{NOG_{PL}} / d_{HICP_{PL}}$, $d_{NOG_{PL}} / d_{IPI_{PL}}$
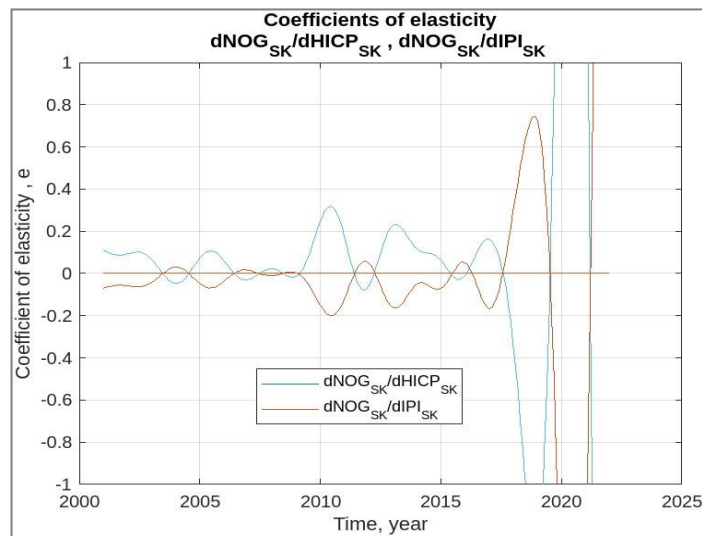
Figure 10. Coefficients of elasticity $d_{NOG_{SK}} / d_{HICP_{SK}}$, $d_{NOG_{SK}} / d_{IPI_{SK}}$

The evidence of above-mentioned results supports the fact that Hypothesis 1 and 2 are more complex and we can state following:

- An increase in the rate of inflation in Poland, Slovakia and the Czech Republic reduces the number of tourists from these countries staying in Czech hotels.
- A decrease in the rate of inflation in Poland, Slovakia and the Czech Republic increases the number of tourists from these countries staying in Czech hotels.
- The increase in the rate of inflation in Germany and Austria increases the number of tourists from these countries staying in Czech hotels.
- A decrease in the rate of inflation in Germany and Austria reduces the number of tourists from these countries staying in Czech hotels.

These statements are based on a higher percentage share of wages in GDP in Germany and Austria, compared with Poland, Slovakia, and the Czech Republic shown in Figure 11. and Figure 12. Additional influencing factor is higher share of the tourism industry in the GDP in Germany and Austria, compared to Poland, Slovakia, and the Czech Republic as well as higher renumeration in Germany and Austria compared to Poland, Slovakia, and the Czech Republic. Residents of Germany and Austria have large incomes compared to residents of Poland, Slovakia, and the Czech Republic. Residents of Germany and Austria pay more for various services compared to residents of Poland, Slovakia, and the Czech Republic, at the same time, these services are of higher quality. More expensive tourist services should be of higher quality, to be able to compete. Thus, residents of Germany and Austria are used to paying dearly for a better service. The tourism industry in Germany and Austria is more developed than in Poland, Slovakia, and the Czech Republic. The exchange rate of the euro against the Czech crown has been relatively stable over the past two decades. On tourist trips, tourists pay not only the cost of staying in hotels, but their payments are related to meals in restaurants, concerts, and other entertainment events.   In case of inflation rate increases in Austria and Germany, the residents of these countries prefer to enjoy their

touristic trips to the Czech Republic instead of in their homeland, since they will be able to purchase more of tourism services in comparable quality in Czech Republic than in their country of origin. In opposite case, the residents of Austria and Germany prefer higher-quality tourist services at home, therefore, the number of accommodations in Czech hotels for residents of Austria and Germany is decreasing. Residents of Poland, Slovakia, and the Czech Republic, having a lower income, prefer to save more with an increase in the rate of inflation, and this also applies to tourist services. In this case, tourists from Poland, Slovakia and the Czech Republic stay less in Czech hotels. On contrary, a decrease of inflation rate growth of residents of Poland, Slovakia, and the Czech Republic, encourages new consumer spending, among which is also the receipt of tourist services on the territory of the Czech Republic, including accommodation in Czech hotels.
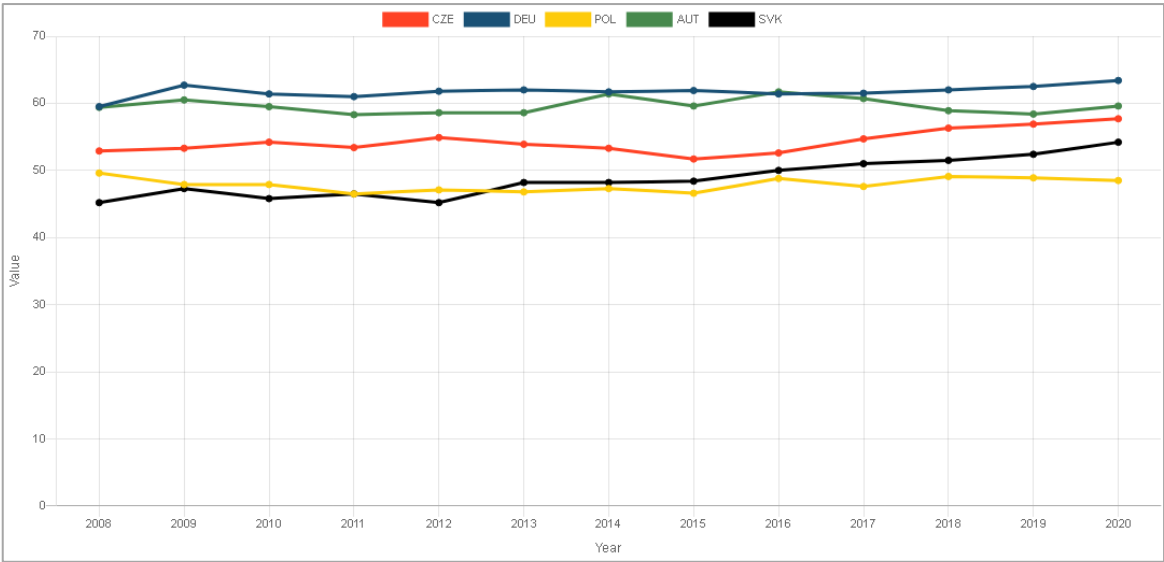
Figure 11. Labor share of GDP, comprising wages and social protection transfers (UNECE, 2022)
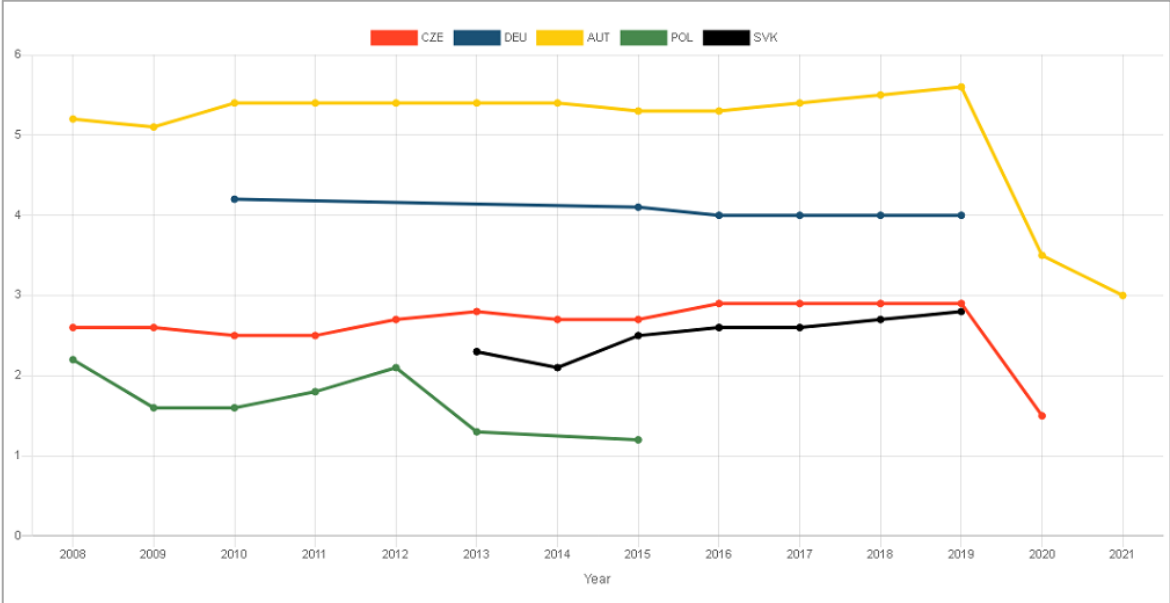
Figure 12. Tourism direct GDP as a proportion of total GDP percentage (UNECE, 2022)

6. Comparing Results

In the following section, we examine the outcomes from the preceding subsection. Investigation was directed to the impact of selected macroeconomic variables as the nominal exchange rate, inflation ratio, GDP per capita and renumeration of employees on tourism demand represented by number of overnights in hotels and similar accommodation. Song et al. (2023) supports these findings by estimating the principal factors influencing tourism demand. They utilized data for both arrivals and expenditures as proxies for tourism demand in their analysis. Although tourism in Czech Republic garners considerable attention from local researchers and sporadically from international scholars, comprehensive investigations into the correlation between macroeconomic variables and tourism demand influencing economic growth remain relatively rare. Contemporary research employs econometric models to explore causal connections, frequently selecting number of arriving tourists or number of overnights often being chosen as the dependent variables and factors as GDP per capita, inflation ratio or exchange rate as independent variables or using empirical and descriptive methods sourcing panel data. In Babecká's study (2013), an examination of tourism demand for the Czech Republic is conducted, focusing on chosen European Union nations via a geographical gravity model. The findings of the analysis indicate a favorable impact of the gross domestic product on tourism demand. In contrast, real exchange rates demonstrate adverse effects. Indrova (2015) provides an empirical analysis of the determinants of international tourism demand to Czech Republic from 38 countries representing the largest share of all foreign arrivals into the country. The paper investigates the period between 2000 and 2012 band is based on the estimation of a dynamic panel data model which accounts for the effects of previous consumption (repeated visits). The results show that tourism demand to Czech Republic is income and price inelastic both in the short and long run (Indrova et al., 2015). Vojtko (2018) founding's in the thematic of exchange rates influence on tourism demand stated that exchange rates can be considered as one of the important determinants in tourism demand analysis especially at the national level, although sensitivity of demand to exchange rate changes may also vary by destination. A generalized linear model was used for data analysis and hypothesis testing. The results showed that there are significant differences in sensitivity of international tourism demand from Eurozone to Czech Republic (Vojtko et al., 2018). Tomáš Jeřábek (2019) investigated the effects of income as gross domestic product, tourism price as the real exchange rate, and travel cost as the price of Brent crude oil have on inbound tourism demand (tourist arrivals) from Poland, Slovakia, Germany, and Austria in the South Moravian Region of the Czech Republic. To achieve this aim, cointegration analysis under the VECM approach was applied. The study of Falk et al. (2023) investigates the short-run impact of the Covid-19 pandemic on the number of domestic overnight stays at the regional level in the summer season 2020. Official data for 65 regions in four countries for the analysis (Austria, the Czech Republic, Germany, and Switzerland). Evidence based on dynamic panel data estimations showed significant negative short-run effects of the Covid-19 pandemic on domestic tourism demand (Falk et al., 2023). The careful selection and definition of variables play a pivotal role in analytical

outcomes. Deciding between the real exchange rate and the nominal exchange rate combined with relative prices, as well as choosing between levels or per capita values, can lead to diverse results. Different choices may yield varied outcomes, and reliance on a specific model's results may result in suboptimal decision-making for policymakers. Furthermore, the choice of the variable serving as the proxy for tourism demand, whether arrivals or expenditures, is of utmost importance due to their distinct relationships with explanatory variables. In the case of Arrivals, GDP per capita emerges as the most influential factor, followed by the exchange rate and inflation. While the first variable is exogenous for most countries, it may indicate significant dependence on specific origin countries. Implementing economic policies to diversify destinations for origin countries could prove effective in reducing reliance on specific sources. Despite expenditures showing a decline, both in per capita and per GDP, policies focusing on influencing expenditures become more critical. Specifically, measures to enhance price competitiveness are crucial, strongly impact spending decisions in Czech Republic.

7. Conclusion

This work analyses the influence of some key macroeconomic determinants, such as the nominal exchange rate, inflation ratio, GDP per capita, and remuneration of employees, on tourism demand, specifically represented by the number of overnight stays in hotels and similar accommodations. To carry out this analysis, we employed a squared model based on the Gauss-Markov theorem, utilizing a dataset covering the years 2000 to 2022 and encompassing data from the Czech Republic, Slovakia, Germany, Austria, and Poland. The primary objective of our model was to assess the influence of inflation, employee remuneration, and the nominal exchange rate on tourism in the Czech Republic. Recognizing the economic instability, we considered wage earnings and asset-based income, both susceptible to fluctuations, which consequently impact individuals' purchasing power. The relationship between the exchange rate, inflation ratio, and tourism demand was identified as significant. In our analysis, we took into consideration the share of wages and the tourism industry in the GDP results, recognizing their importance in shaping the overall economic landscape. We cannot reject the hypothesis 1 of a GDP/IPI impact on annual tourism demand neither Hypothesis 2. about a negative association between annual tourism demand and inflation ratio. Results differs depending on the demand´s country of origin. An increase in the rate of inflation in Poland, Slovakia and the Czech Republic reduces the number of tourists from these countries staying in Czech hotels. A decrease in the rate of inflation in Poland, Slovakia and the Czech Republic increases the number of tourists from these countries staying in Czech hotels. The increase in the rate of inflation in Germany and Austria increases the number of tourists from these countries staying in Czech hotels. A decrease in the rate of inflation in Germany and Austria reduces the number of tourists from these countries staying in Czech hotels. There is evidence that the relationship between the exchange rate, inflation ratio, and tourism demand was identified as significant. In our analysis, we took into consideration the share of wages and the tourism industry in the GDP results, recognizing their importance in shaping the overall economic landscape. The findings

from this study contribute to a deeper understanding of the intricate dynamics between macroeconomic variables and tourism demand, offering practical insights for stakeholders involved in the planning and management of the tourism sector.

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E-Invoice Adoption in the Czech Republic (Forms, Exchange Channels, and Formats)

Michal KUBĚNKA[1], Irena HONKOVÁ[1] and David ZEJDA[2]*

[1] University of Pardubice. Pardubice, Czech Republic; michal.kubenka@upce.cz; irena.honkova@upce.cz

[2] University of Hradec Králové, Hradec Králové, Czech Republic; david.zejda@uhk.cz

* Corresponding author: david.zejda@uhk.cz

Abstract: The e-invoicing market is experiencing growth propelled by the global trend towards digitalization and automation. This paper aims to assess the status of e-invoice usage in the Czech Republic in the context of recorded usage trends, with a particular emphasis on whether the formats most widely used are suitable for automated processing. The research is based on both primary data obtained from 258 Czech companies and secondary data sourced from the Czech Statistical Office. Our data have shown that 63.19% of invoices are sent electronically compared to 36.81% in a hard copy. Among invoices exchanged electronically, 1.23% were downloaded from a supplier's system, 58.36% were exchanged via email in a non-structured format, 3.07% in a structured format, and finally, only 0.52% were sent through the official data box, endorsed by the Czech government. Surprisingly, a downward trend regarding machine-readable invoicing was identified in the available data. For data analysis, linear regression, confidence interval, descriptive statistics and Friedman test were used.

1. Introduction

Electronic invoicing or e-invoicing can be defined as an information system service that gathers data from a business transaction and transmits it through a network (Lian, 2015). Thus, it is a digital approach which involves creating, sending, receiving, and processing invoices among businesses. In contrast to traditional paper-based invoicing, which involves physical documents, e-invoicing relies on electronic formats and allows automated systems to partially or fully manage the invoicing process.

Both manufacturing and non-manufacturing businesses shall '*apply lean concepts across all organizational functions*' (Zemanová & Slavík, 2016) to streamline operations and boost efficiency. Alongside global trends toward digitalization and automation, traditional paper-based invoicing is supposed to be gradually substituted with quicker, more precise, and cost-effective electronic alternatives. The concept of e-invoicing arises as a contemporary, dependable, and effective approach for managing and processing invoices related to products, services, taxes, and various goods, eliminating the necessity for paper (Matus et al., 2017). The ongoing digital transformation initiatives within businesses involving key

processes such as resources management, stock management and production are contributing to the adoption of e-invoicing as part of broader digitization efforts. For example, e-invoicing may be aligned with automated payment control and payment processing solutions (Sungkur et al., 2016).

In addition to time and cost savings, e-invoicing supports privacy, security, reliability, and resolution of potential disputes (Sungkur et al., 2016), authentication, content integrity, non-repudiation of origin and receiver, confidentiality and privacy, sequence integrity, and relevant policies (Cuylen et al., 2016). Increased accuracy and reliability of invoicing contribute to trust among stakeholders. As companies expand their operations across borders, the inefficiencies, delays and other limitations of traditional paper-based invoicing become even more evident (Abidin et al., 2016). E-invoicing facilitates seamless and real-time exchange of invoices between international partners, thus helping overcome geographical barriers. The emphasis on cloud-based solutions, mobility, and remote work is further highlighting the necessity for electronic and interconnected invoicing processes. E-invoicing is becoming an important technology in facilitating faster and more efficient financial transactions within increasingly interconnected business environments.

Both businesses (Olaleye & Sanusi, 2019) and the public sector (Fuka & Baťa, 2022) are acknowledging the environmental impact of paper-based processes, including resource consumption and waste generation. As a result, the growing emphasis on sustainability and environmental responsibility is also contributing to the expansion of the e-invoicing market.

Since e-invoices may serve as a tax collection and reporting instrument, numerous governments and regulatory bodies are encouraging or mandating businesses to adopt electronic invoicing primarily to combat tax evasion, mitigate fraud, and enhance overall financial transparency. For example, automated electronic systems are being deployed for value-added tax (VAT) reporting (Zorina et al., 2022). As more convenient, integrated, transparent, and fast such tax reporting systems made tax collection and tax administration more effective and efficient (Wagiman et al., 2023). Related regulations may serve as catalysts for the whole e-invoicing market, compelling businesses to embrace e-invoicing to maintain compliance and avoid potential penalties (Nalcaci, 2016).

In an e-invoicing system, invoices are electronically generated and can be transmitted to recipients through various digital channels, such as email, online portals, or electronic data interchange (EDI) systems. These invoices follow standardized formats, enabling seamless integration with accounting software, enterprise resource planning (ERP) systems, and other financial management tools. Software tools created to support e-invoicing are gradually available in various countries (Pugliese et al. 2021; Rubio & Gaitan, 2021; Pinheiro & Frega, 2016).

The ongoing digital revolution and swift progress in technologies and concepts such as industry 4.0, cloud computing, artificial intelligence (AI) and machine learning (ML) are further reshaping the landscape of the e-invoicing market. Advanced automation technologies incorporated into e-invoicing platforms may fundamentally streamline and optimize the entire invoicing process (Azman et al., 2021). These technologies facilitate the extraction of pertinent information from invoices, validation of data accuracy, and even

prediction of potential discrepancies. Blockchain and digital ledger technologies (DLT), capable of offering secure and immutable records of transactions, are being examined in the context of e-invoicing, to ensure data integrity and diminish the risk of fraud (Narayanam et al., 2020; Liu, 2018). Computational fraud-detecting methods such as Benford Analysis may be integrated into e-invoicing systems (Nalcaci, 2017). Advanced automated systems may sieve correct invoices reasonably accurately e.g. by Chang et al. (2020) whose system demonstrated sensitivity above 95%.

Despite its positive effects such as automation of routine processes, time and savings, teamwork, information sharing and simplicity, e-invoicing adoption faces challenges such as conservatism and resistance, (overly) fast technological progress, insufficient legislation, disrupting impacts on the labour market, or issues related to document conversions (Stefanovova et al., 2020). Because of the multi-criteria nature of reasoning about complex data such as an invoice, user-friendly interface and visualization of data processing results of an automated invoicing solution are vital prerequisites of its adoption (Sedlák et al., 2015). The e-invoicing landscape has been visualized as a conceptual map (Figure 1).
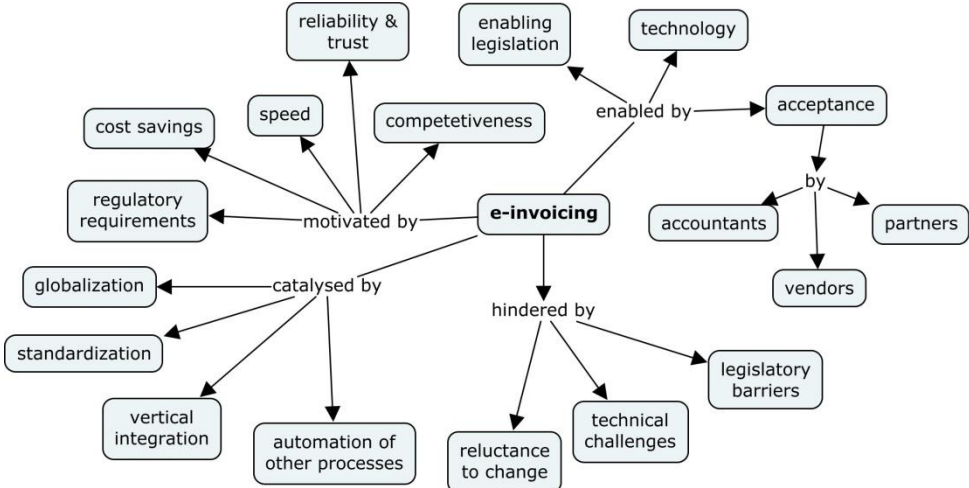
Figure 1. Conceptual map of the e-invoicing landscape from the perspective of a business owner (authors using CmapTools)

In 2009, ISDOC (Information System Data Object Content) was declared a standardized format of invoices (electronic tax documents) in the Czech Republic, replacing various proprietary formats. As a free-to-use format, it allows the transmission of tax documents among parties, including small businesses and self-employed individuals, without additional costs. ISDOC complies with Czech VAT law requirements and may include a qualified electronic signature, issued by a qualified certification authority, allowing easy verification of the authenticity of the document.

ISDOC documents can be exchanged via various channels, such as by an email or a government-endorsed data box (Digital and Information Agency, 2023), made downloadable over the Internet, or even on physical storage media. Current versions of ISDOC format mostly follow an internationally recognized e-invoice format UBL, adjusted mainly to reflect Czech specifics, such as the tax advance payment list. Besides the standard

tax invoice, ISDOC offers 5 additional document types; however, it does not support related types of documents such as orders or receipts.

Technically, ISDOC is in XML format with a signature implemented according to the XML Signature standard. The structured invoice file name in ISDOC format usually ends with a *.isdoc* extension and is readable by an ISDOC reader software. Commonly a printable and human-readable version of the invoice, which may carry the visual identity of the issuing party, is shared together with ISDOC, either as a separate PDF file or in a hybrid invoice file format. The first hybrid file format is ISDOCX, technically an ISDOC together with PDF and other possible attachments compressed in a ZIP archive with *.isdocx* extension, which is a similar approach as for OpenDocument (e.g., *.odt*) and Office Open XML (e.g., *.docx*). A slightly newer approach makes use of PDF A/3 format, where ISDOC is embedded in a PDF file, directly readable by any PDF reader. Though not as versatile as ISDOCX, ISDOC in PDF A/3 is gaining popularity, possibly for its user-friendliness.

The strive for process efficiency both in the private and public sector, globalization challenges, and environmental concerns, together with advancement in relevant enabling technologies, such as cloud computing, digital signing, AI and ML are behind the uptake of e-invoicing. The paper evaluates the current use of e-invoices in the Czech Republic in the context of past development. Therefore, a hypothesis has been established as such that in the monitored years, there has been no development in the use of e-invoices. Furthermore, the paper assesses whether the electronic formats which are being used allow automated processing or not.

2. Data and Methodology

The research is based on both secondary data from the Czech Statistical Office (2013; 2014; 2015; 2016; 2017; 2019; 2020) and primary data from our own research. Linear interpolation was used to fill in the missing years in the Czech Statistical Office data series. Other available relevant studies were used to compare our results (EY, 2019; Koch, 2020). The hypothesis that in the monitored years, there has been no development in the use of e-invoices. will be confirmed or refuted by the Friedman test (Friedman, 1937). The Friedman test is a non-parametric statistical test developed by Milton Friedman. Similar to the parametric repeated measures ANOVA, it is used to detect differences in treatments across multiple test attempts. The Friedman test is widely supported by statistical software packages and used.

Primary data collection was necessary due to the absence of secondary data covering years beyond 2021. The primary research in the field of invoice formats in the B2B sector involved 258 Czech companies with 10 or more employees. The sample of companies was obtained by randomly selecting companies from the entire Czech Republic through students of the Faculty of Economics and Administration during the autumn of 2023.

At first, the invoices were classified according to their form as paper-based or electronic; electronic invoices were classified according to the exchange channel as downloaded from a supplier's system, sent via an official data box, referred to also as a data locker, or via email; invoices sent via email were classified according to the format used as structured or non-

structured (Figure 2). Since the share of invoices delivered via data box or downloaded from a supplier's system was negligible, the format of invoices delivered via these two channels was not determined.
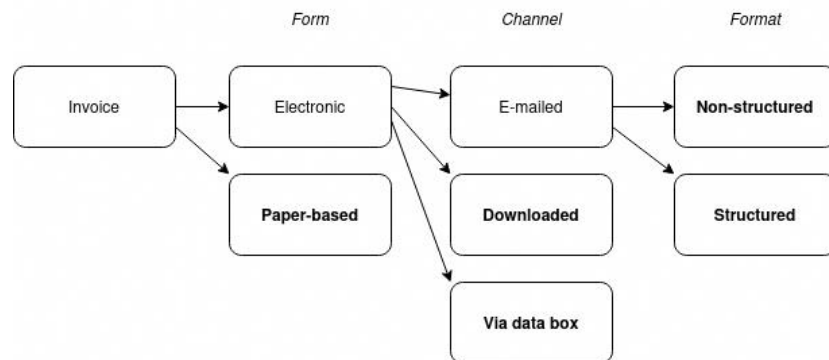
Figure 2. Form, channel, and format classification system with resulting used categories highlighted (authors using drawio.com)

The final classification system consisted of lists of the classification graph (Figure 1):

1. Invoices in paper-based form (hard copy),
2. Electronic, downloaded through the supplier's application,
3. Electronic, sent through an official data box,
4. Electronic, sent via email, only in a non-structured format, such as *.pdf* (not PDF A/3) or *.docx, .doc, .odt, .tif, .jpeg, .png;*
5. Electronic, sent via email, in a format containing structured data, suitable for automatic processing such as *.edi, .xml, .csv, .json,* or the aforementioned *.isdoc* and its variants (*.isdox, .pdf* with ISDOC in its PDF A/3 extension).

After calculating descriptive statistics on our dataset, linear regression analysis has been conducted in Statistica Software. The confidence interval π for the empirical study was determined according to Pacáková (2003):

$$P\left(p - z_{1-\frac{\alpha}{2}} * \sqrt{\frac{p(1-p)}{n}} < \pi < p + z_{1-\frac{\alpha}{2}} * \sqrt{\frac{p(1-p)}{n}}\right) = 1 - \alpha \qquad (1)$$

where:

p – found frequencies of forms of sending invoices in percentages,

n – the size of the base π (the number of companies in the data sample),

α – determined at the level of 5%.

3. Results

We have divided the research into a part dealing with the invoice forms and exchange channels and a part dealing with invoice formats (structured vs. non-structured).

3.1. Forms of Invoices and Exchange Channels

Our research has shown that 63.19% of invoices are sent electronically and 36.81% of invoices are sent in hard copy, delivered either in person or by post. The invoices sent electronically contain both structured and non-structured formats. The predominant usage

of electronic form of invoices matches the results of other relevant available studies (Czech Statistical Office, 2016; EY, 2019; Koch, 2020), see Table 1.

Table 1. Forms of sending invoices

Form	Czech Statistical Office (2016)	EY (2019)	Koch (2020)	Own research (2023)	Own research (2023) - confidence interval π
Paper	23.10%	32%	30%	36.81%	(30.92; 42.70)
Electronic	76.90%	68%	70%	63.19%	(57.30; 69.08)
Σ	100.00%	100%	100%	100%	x

Table 2. Companies that also send invoices in paper form (%)

Sector – CZ NACE	2015	2016[1]	2017	2018[2]	2019[2]	2020	Trend[3]
C (10–33) Manufacturing industry	65.4	18.7	87.9	85.5	83.0	80.5	Decline
D. E (35–39) Energy	64.6	19.0	88.0	90.9	93.8	96.7	Growth
F (41–43) Building industry	55.7	29.4	96.9	93.4	89.8	86.3	Decline
G (45–47) Wholesale and retail sale; Repair and maintenance service of motor vehicles	63.0	20.9	90.8	87.7	84.5	81.4	Decline
H (49–53) Transport and storage	48.8	40.7	91.7	90.9	90.1	89.3	Moderate decline
I (55–56) Accommodation, Food and Beverage	45.0	30.2	87.6	82.5	77.4	72.2	Decline
J (58–63) Information and commun. activities	65.7	10.6	78.3	73.4	68.4	63.4	Decline
L (68) Real Estate Activities	46.6	32.4	90.2	88.3	86.5	84.6	Decline
M (69–75) Scientific and technical activities	62.1	18.3	88.5	85.3	82.2	79.0	Decline
N (77–82) Administrative and support activities	58.1	23.7	75.6	76.1	76.5	77.0	Moderate growth
Total (weighed average)	60.0	23.1	88.8	86.1	83.4	80.8	Decline

[1]Companies sending paper-only invoices. [2]Values determined by linear interpolation from 2018 and 2020. [3]Linear trend determined from values over the last 4 years.

Table 3. Companies sending invoices via data boxes (v %)

Sector – CZ NACE	2013	2014	2015	2016	2017	2018[1]	2019[1]	2020	Trend[2]
C (10–33) Manufacturing industry	1.8	2.5	2.9	4.9	4.7	4.8	5.0	5.1	Decline
D. E (35–39) Energy	4.9	7.3	3.8	10.6	6.5	8.4	10.4	12.3	Growth
F (41–43) Building industry	1.6	3.8	1.7	5.9	7.8	8.1	8.5	8.8	Moderate growth
G (45–47) Wholesale and retail sale; Repair and maintenance service of motor vehicles	2.1	2.7	3.0	4.0	6.2	5.3	4.3	3.4	Decline
H (49–53) Transport and storage	2.5	2.6	2.8	3.5	3.8	4.4	5.0	5.6	Growth
I (55–56) Accommod., Food and Beverage	2.2	3.9	2.0	6.5	7.5	6.6	5.7	4.7	Decline
J (58–63) Information and comm. activities	6.3	8.1	9.0	12.1	15.2	14.4	13.7	13.0	Decline
K (64–66) Banking and Insurance	5.4	4.0	3.0	5.3	7.4	6.9	6.3	5.7	Decline
L (68) Real Estate Activities	3.8	7.4	8.4	9.9	16.9	15.0	13.1	11.2	Decline
M (69–75) Scientific and technical activities	1.7	3.8	3.6	4.6	7.7	8.2	8.6	9.1	Growth
N (77–82) Administrative and support act.	2.3	3.5	3.4	5.6	7.2	6.9	6.6	6.4	Decline
Total (weighed average)	1.8	2.5	2.9	4.9	4.7	4.8	5.0	5.1	Decline

[1]Values determined by linear interpolation. [2]Linear trend determined from values over the last 4 years.

Although the results seem positive, a large proportion of companies use the paper form, possibly alongside an electronic delivery (Table 2). It might be due to the legislative regulation in Czechia which requires the customer's prior consent to electronic form of invoice. For 2016 a dataset with a different structure was available (Czech Statistical Office, 2016), showing the paper-only form of invoicing with a weighted average of 23.1% among all sectors (Table 2).

In the case of the form of sending invoices via official data boxes, the Czech Statistical Office data do not distinguish structured or non-structured formats. The advantage of using government-endorsed data boxes is increased confidence in the authenticity of the sender (invoice issuer) and the integrity of the invoice contents. However, their use is rather negligible (Table 3).

3.2. Formats of Sending of Invoices

Surprisingly, the usage of structured invoice formats (i.e., *.edi*, *.xml*, *.csv*, *.json*, *.isdoc*) suitable for automatic processing has declined over the years 2013-2020 among most sectors (Table 4), except CZ NACE Manufacturing and distribution of energy, gas, water, heat, and related waste management activities – D, E (35–39). Conversely, usage of either paper invoices or electronic invoices in non-structured formats (i.e., *.docx*, *.doc*, *.odt*, *.tif*, *.jpeg*, *.png*, *.pdf* which is not a PDF A/3) must have increased among most sectors.

Table 4. Companies sending invoices in automated data processing format (%)

Sector – CZ NACE	2013	2014	2015	2016	2017	2018[1]	2019[1]	2020	Trend[2]
C (10–33) Manufacturing industry	13.2	14.7	15.6	21.8	15.4	15.3	15.2	15.0	Decline
D. E (35–39) Energy	11.0	8.7	10.8	20.8	10.4	10.6	10.8	11.0	Growth
F (41–43) Building industry	6.9	5.8	5.2	13.9	6.5	5.7	5.0	4.2	Decline
G (45–47) Wholesale and retail sale; Repair and maintenance service of motor vehicles	15.5	17.7	16.6	22.4	22.1	20.5	19.0	17.5	Decline
H (49–53) Transport and storage	8.0	7.5	9.5	13.5	11.1	10.9	10.7	10.5	Decline
I (55–56) Accommodation, Food and Beverage	7.1	7.5	8.9	13.7	9.2	8.3	7.3	6.4	Decline
J (58–63) Information and comm. activities	14.1	15.1	13.9	23.4	16.9	16.7	16.4	16.2	Decline
K (64–66) Banking and Insurance	7.9	9.0	x	x	x	x	x	x	x
L (68) Real Estate Activities	5.4	6.8	7.7	8.3	6.4	5.8	5.1	4.5	Decline
M (69–75) Scientific and technical activities	7.7	9.3	11.7	11.5	13.2	11.9	10.6	9.4	Decline
N (77–82) Administrative and support act.	9.1	11.1	12.9	15.8	11.4	11.0	10.5	10.0	Decline
Total (weighed average)	11.3	12.5	12.9	18.4	14.4	13.7	12.9	12.2	Decline

[1]Values determined by linear interpolation. [2]Linear trend determined from values over the last 4 years.

Table 5. Average share of e-invoices sent by companies in a standardized format in the total number of issued invoices (%)

Sector – CZ NACE	2016	2017	2018[1]	2019[1]	2020	Trend[2]
C (10–33) Manufacturing industry	9.6	6.3	6.5	6.7	6.9	Moderate growth
D. E (35–39) Energy	5.9	4.1	4.2	4.4	4.5	Moderate growth
F (41–43) Building industry	5.0	2.8	2.1	1.5	0.8	Decline
G (45–47) Wholesale and retail sale; Repair and maintenance service of motor vehicles	9.4	7.1	6.7	6.2	5.7	Decline
H (49–53) Transport and storage	3.9	4.4	4.0	3.7	3.3	Decline
I (55–56) Accommodation, Food and Beverage	5.1	3.8	3.6	3.3	3.1	Decline
J (58–63) Information and communication activities	14.4	8.6	8.6	8.6	8.6	Stagnation
L (68) Real Estate Activities	4.7	2.1	1.9	1.8	1.6	Decline
M (69–75) Scientific and technical activities	7.2	4.6	4.5	4.4	4.2	Decline
N (77–82) Administrative and support activities	7.9	6.6	6.2	5.9	5.5	Decline
Total	8.0	5.6	5.4	5.2	5.0	Decline

[1]Values determined by linear interpolation. [2]Linear trend determined from values over the last 4 years.

The latest recorded weighted average of use of ISDOC, a standardized and dominant e-invoicing format in Czechia, for issuing invoices (Czech Statistical Office, 2020) is 5% with a noticeable downward (Table 5). The statistical Friedman test has been conducted to evaluate the hypothesis: "In the monitored years, there is no development in the use of e-invoices". The tested criterion was found to have a value of 35.04, with a critical limit of 9.49. It follows from this that individual years differ statistically, i.e., that we reject the null hypothesis. From this, it can be deduced that a downward trend is observed across sectors.

Since official statistics on electronic invoice usage for years 2021+ are not available, primary research was carried out with a focus on forms of invoices, the exchange channels and their format (structured vs. non-structured), see Table 6.

Table 6. Forms, exchange channels and formats of invoices in the Czech Republic in 2023

Category[1]	Modus	Q1	Median	Q3	Min	Max	Average
1. paper	30	27	37	55	9	84	36.81%
2. download	0	0	1	3	0	10	1.23%
3. non-s. email	57	49	59	78	9	90	58.36%
4. s. email	0	0	2	7	0	17	3.07%
5. databox	0	0	0	1	0	7	0.52%

[1]1. Paper-based invoice forms. 2. Electronic invoice forms downloaded through the supplier's application. 3. Electronic invoice forms sent via email in an unstructured format 4. Electronic invoice forms sent via email in a structured format 5. Electronic invoices sent through an official data box; Source of tables: authors

Non-structured formats include paper-based (1) and sent via email in a non-structured format (3). The share of invoices sent via e-mail in a structured format (4) was only 3.07%. Since the share of invoices downloaded through the supplier's application (2) and invoices delivered through a data box (5) were found negligible, their format (structured or non-structured) was not distinguished.

4. Discussion

E-invoicing has many notable advantages such as facilitating overall invoicing process optimization (Matus et al., 2017; Zemanová & Slavík, 2016). Potential billing cost savings have been demonstrated e.g. by Cedillo et al. (2018) who calculated the drop from €8.60 (paper form), through €2.11 (scanned), to €1.89 (e-invoice). E-invoicing may be connected with other automated systems such as for payment processing (Sungkur et al., 2016) or tax reporting (Nalcaci, 2016; Wagiman et al., 2023; Zorina et al., 2022). It may ensure authenticity and data integrity, thus diminishing the risk of fraud (Cuylen et al., 2016; Narayanam et al., 2020; Liu, 2018; Nalcaci, 2017; Chang et al., 2020) and reducing environmental impacts (Olaleye & Sanusi, 2019; Fuka & Baťa, 2022). The advantages are further highlighted for globalized businesses (Abidin et al., 2016). E-invoicing may go beyond simple data exchange thanks to promising relevant AI and ML technologies (Azman et al., 2021).

In the Czech environment, sending invoices via official data boxes has additional advantages, namely guaranteed authenticity and integrity. At the same time, it is a possible and somehow preferred way to comply with the obligation to submit invoices in electronic

form, which applies to trading with state entities. However, this obligation applies only to business entities defined by § 31 paragraph 2 letter a) of Act No. 235/2004 of the collection, on value-added tax. Sending B2B invoices via official data boxes is not free of charge, however. Though cheaper than postal services, the cost of 10 CZK per message may still discourage businesses which issue large quantities of invoices. Technical aspects of data boxes may prove as barriers of use for small non-tech businesses. A good prerequisite for the broader adoption of e-invoicing in structured form in Czechia is rather the prevalent use of e-mail as the most common channel for invoicing (EY, 2019). Important is the availability of a standardized format of electronic invoice (ISDOC), supported to a certain degree by most ERP systems currently used in Czechia.

In 2019, the share of electronic form of invoices in the total number of invoices among businesses in the Czech Republic was 32%, which was above the European average of 25% (EY, 2019). The survey also indicated that 57% of Czech companies planned to increase the share of electronic invoices in the next three years, which neither our survey nor other data confirmed. The share of electronic invoices in the total number of business-to-business (B2B) and business-to-government (B2G) invoices issued in the Czech Republic in 2020 was about 30%, which is slightly above the European average of 27% (Koch, 2020). Thus, the remaining 70% of invoices were in paper form. While the survey of the Czech Statistical Office showed a share of 76.9% in 2016, our current research indicates a decrease to 63.19%.

However, despite the technological prerequisites such as widely used electronic form of invoices, only around 3% of invoices in Czechia are exchanged in a structured, machine-readable format. Similarly, only 2% of respondents received structured electronic invoices in Poland in 2018 and their awareness and readiness to implement electronic invoicing was considerably low (Dobrzeniecka, 2018). Not only that the current level of machine-readable e-invoice adoption in Czechia is low, but the research indicated a decreasing trend in using electronic exchange channels for sending invoices in Czechia.

The low rate of usage of machine-readable formats and the downward trend in e-invoicing in Czechia are not just surprising, but even alarming findings, given the ongoing automation and digitization of the whole society, and the availability of relevant technology. Slow adoption of automation in invoicing (or even de-automation, as indicated by the trends) might affect the competitiveness of the Czech economy. Croatia may serve as an interesting use case for comparison and inspiration, where bolder normative acts which regulate the use of electronic signatures and issuance of e-invoices were adopted a few years ago. Decman et al. (2019) analysed the state and trends in the digitalization of accounting and tax processes in the country; the research methodology included secondary research of relevant literature as well as primary desk research. Other sources of inspiration may be found far beyond Europe, such as in Brazil, where successful adoption of e-invoicing was reported years ago (Pinheiro & Frega, 2016).

To find out the reasons behind the disappointing situation in Czechia, to predict how quickly will businesses eventually adopt e-invoicing and automated e-invoice processing, or how to support the adoption either legislatively or technically, subsequent research will

have to follow. Known barriers to e-invoice adoption, such as the accounting technicians do not know them and do not want to use them or technical limitations of e-invoice import functions of current ERPs (Stefanovova et al., 2020) will have to be considered.

The limited adoption of structured-format invoices might also be attributed to the following two factors. Firstly, for the purpose of potential scrutiny by tax authorities, maintaining data integrity is crucial, a guarantee achievable only through an electronic signature or the use of official data boxes. There is no recent substantial change in Czech legislation on this matter which would follow either the technological advancements or legislative development in Europe and beyond. Czech legislation doesn't specifically mandate accounting entities to archive or exchange certain documents in digital form, such as those related to transactions above a certain value. However, it does impose requirements on maintaining the so-called immutability of electronic copies of documents and ensuring their conformity with the original. Limited durability of qualified electronic signatures may be an issue. Secondly, in accordance with prevailing legislation, the recipient must provide consent for electronically transmitted invoices, making further artificial barriers to broader e-invoice adoption. A significant shift toward the digitalization and automation of invoicing and accounting practices in Czechia will possibly have to be dictated by European directives.

5. Conclusions

As a main takeout of the research, e-invoicing allowing automated processing is underutilized in Czechia. Although ISDOC is a standardized format endorsed by the government and most current ERPs in Czechia can both issue and import it, only approximately 3% of invoices are currently issued in ISDOC or any other structured machine-readable format. With low numbers of invoices issued in structured formats, automated importing of machine-readable invoices is not commonplace. Worryingly, the trend in the adoption of e-invoicing in Czechia is rather downward, as supported by various data sources as well as indicated by the results of the tested hypothesis.

The low share of invoices in a structured format might partly be attributed to the Czech legislation which states that for the purpose of tax office control, integrity of invoice data has to be ensured. Invoice integrity can only be guaranteed through an electronic signature or using official data boxes and neither of the options is free of disadvantages. Also, according to outdated legislation, the recipient must consent to electronically delivered invoices, forming an additional barrier to e-invoice adoption. Other reasons may be rather technical, such as the rather low quality of e-invoice import functions in current ERPs which are not user-friendly and comprehensive enough, or psychological, such as the resistance of accounting technicians. Further research might analyze more in detail both the reasons and potential solutions.

Conflict of interest: none.

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Social Benefits Fraud Czech Case Study

Gabriela KUKALOVÁ*, Lukáš MORAVEC, Jana HINKE, Michaela CHLADÍKOVÁ and Aranka BERGNEROVÁ

University of Life Sciences Prague, Prague, Czech Republic; kukalova@pef.czu.cz; moravec@pef.czu.cz; hinke@pef.czu.cz; xchlm022@studenti.czu.cz; bergnerova@pef.cu.cz

* Corresponding author: kukalova@pef.czu.cz

Abstract: The battle against social security benefit fraud has become a priority in a number of countries given that expenditure on social benefits accounts for a significant portion of public expenditure as a whole. The aim of this article was to quantify irregular payments of all sixteen non-insurance social benefits paid out in the Czech Republic and to determine how they are settled and the recovery rate for the national budget and. The study works with a unique set of data from the years 2016-2020, collected by summarizing information from the application programs of the Labour Office of the Czech Republic. The following benefits were identified as those accounting for the highest claims: childcare allowance, subsistence allowance, housing benefit, care allowance, and supplementary housing benefit. The claim recovery rate for the national budget stands at 71%, whereby a progressive and continuous decline in the aggregate amount of claims was proven.

Keywords: social benefit; claim; settlement; expert interview; recovery rate

JEL Classification: H39; H53; H55

1. Introduction

The social security system provides the citizens of a particular state with security (social benefits) if social situations should arise. Social security is identified as an important component of social policy in the socio-economic development strategy of a country (Hieu, 2021). Social security contributions are part of the tax burden on labour. Krajňák et al. (2022) evaluates the relationship between the tax burden on labor and magic quadrangle indicators. Social security benefits account for a considerable portion of public expenditure in a number of countries. Blanco (2021), for example, focuses on the general issue of public income and expenditure in relation to social security. Mertl (2018), meanwhile, considers in his paper the fiscal significance of insurance benefits and non-insurance benefits within the Czech social security system. In their paper, Romer and Romer (2016) analyse the macroeconomic impacts that raising social security benefits had between 1952 and 1991.

Most countries also have to continually deal with their social security policy and how the level of benefits is set within the social security system. Perez et al. (2021) state that several political alternatives can theoretically be implemented in order to secure the long-term sustainability of the social security system in the USA. The political stability of funded social security is analysed in a study by Beetsma et al. (2021). Maritnez et al. (2021) carried out an analysis of scientific literature to concern the sustainability of welfare systems. Increased

expenditure and the sustainability of social systems were also manifested in connection with the Covid-19 pandemic. Peeters (2021) looks in more detail at the extent to which EU law impacts on the freedom of Member States to choose (additional) taxes or social contributions as a means of funding deficits in their social security systems. As Orton et al. (2021) have said, Covid-19 revealed the deficiency of British social security and a lack of consensus among progressive stakeholders over what kind of system would be better.

The provision of benefits comes with the risk of fraud, abuse, or overuse. Cullis et al. (2015) claimed, the decision to evade tax or abuse social benefits depends on the net expected benefit that the individual in question gains. Social benefit abuse is a problem with which all countries with advanced social systems have to contend. Overuse (abuse, fraud) is perceived by the public as the Achilles heel of welfare state legitimacy (Roosma et al., 2016). Moro-Egido and Solano-García (2020) tested whether the perception about benefit fraud may produce different effects on preferences over the size of the welfare state. The results of the study suggest that social policies targeting the deterrence of benefit fraud (such as higher penalties and more frequent benefit investigations) increase the high earners' willingness to pay taxes, and subsequently support broader social security. On the other side, a social security system might also have an impact on education, birth rate, or the growth of GDP (Chen & Miyazaki, 2021). Considering the abuse of social security systems, a number of countries are dealing with methods and procedures in the battle against social benefit fraudsters. Three general types of intervention are recommended all over the world: prevention, detection, and deterrence.

Prevention is linked to effective administration and control by the public administration. Effective public administration and control reduces the risk of abuse of social systems. Information technologies play a highly important role in the process of improving the quality and increasing the effectiveness of the public service (Pribil et al., 2005). Hornyák Gregánová and Országhová (2019) assess the success of implementing effective public administration. According to Okhotsky et al. (2019) public administration reforms must be accompanied by measures for their effective implementation. The measures should be politically, legally, and economically well-grounded, should be targeted, implemented systematically and continuously (Okhotsky et al., 2019).

The aim of this article was to quantify irregular payments of all sixteen non-insurance social benefits paid out in the Czech Republic and to determine how they are settled and the recovery rate for the national budget and. The aim is to stimulate authors from other countries to carry out similar investigations and in doing so open up space for comparative analyses, assessment of the effectiveness of individual solutions, and as the case may be further research.

2. Methodology

The authors, taking the findings presented into consideration, decided to deal with the issue of social benefit abuse in case studies in the Czech Republic, the aim of which is to quantify unduly paid benefits, determine how they are settled, and the recovery rate for the national budget. The social benefits for which the value of claims is the highest were also considered from the perspective of how such claims arise.

Data for the period 2016 to 2020 was used (available on 31.12.2021). The study works with a unique data set obtained by summarizing information from the application programs used by the Labour Office of the Czech Republic and its branches, since, when collecting data, there was no comprehensive program in place at those offices that would monitor the volume of quantified claims for the entire authority, or any onward processing according to the method of settlement and the type of benefits. The actual processing of benefits (submitting applications, accepting, or rejecting a claim for benefit, the payment of benefits, and the quantification of claims) was divided into two application programs. One of them (connected nationwide) was the "Okcentrum" program, which processed foster care benefits, state social support, and benefits for disabled people. The second was the "OKnouze/OKslužby", in which benefits provided to people in material distress and care allowances are registered. According to internal service regulations, the claims themselves are monitored and thereafter settled only at the regional workplace at which they arose, resulting in the need for synthesis of data from the fourteen regional branches of the Labour Office in the Czech Republic. In order to identify the reasons behind undue payments, the authors conducted a field survey, choosing the method of expert interviews of a systematic nature. Expert interviews focused on the uniqueness of the knowledge of experts and when being conducted the emphasis was placed on the comparability and connectivity of information. All interviews proceeded the same way based on a pre-defined structure. A field survey was conducted in the Czech Republic in 2020 and 2021, specifically at the 14 regional branches of the Labour Office. Two to four experts were interviewed at each regional branch, by a single interviewer. The interviews revealed the reasons for undue payments having arisen and how often they arose at the workplaces of the experts.

It is impossible to undertake a direct comparison with the results of other authors in light of the fact that no similar studies of the size, structure, and development of unduly drawn social benefits have been carried out in the Czech Republic or in surrounding countries.

3. Results

All 16 non-insurance social benefits provided in the Czech Republic were analysed in the reference period, and the level of claims arising from the issue of undue payment decisions by individual specialised divisions was ascertained.

3.1. Structure of Claims and Their Development

The values of unduly drawn benefits are shown in the Table 1 which follows, which orders benefits by the size of unduly drawn benefits (altogether for the entire reference period) in descending order.

The total claims of unduly drawn benefits are CZK 1,336,472,103 (in the period 2016-2020), a very significant amount that could evidently contribute to the budget of the Czech Republic, in particular the major deficit budget of the final year of the analysed period (Table 1). The highest number of quantified claims during the reference period fell to childcare allowance (the sum of CZK 332,759,041), one element in the system of state social support benefits. Next in line, 16% lower in volume in terms of quantified undue payments, is subsistence allowance from the system of benefits provided to persons in material distress

Table 1. Volume of unduly drawn amounts – non-insurance social benefits – 2016 to 2020 (in CZK) (own processing according to data from the Labour Office of the Czech Republic application database, 2021)

Reference period	2016	2017	2018	2019	2020
Type of benefit/size of benefit	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %
Childcare allowance	81,383,740 25.34	75,008,585 23.62	71,409,756 24.99	60,180,461 25.25	44,776,499 25.80
Subsistence allowance	27,622,567 8.60	92,149,640 29.02	70,136,100 24.54	61,294,767 25.72	29,884,613 17.22
Housing benefit	56,140,189 17.48	51,158,220 16.11	43,216,748 15.12	40,449,985 16.97	36,100,439 20.80
Care allowance	24,450,456 7.61	36,675,684 11.55	27,506,764 9.63	33,619,380 14.11	30,563,072 17.61
Supplementary housing benefit	69,798,667 21.73	8,108,307 2.55	18,608,513 6.51	8,124,307 3.41	9,390,460 5.41
Contribution toward a special aid	20,851,852 6.49	24,788,444 7.81	27,812,132 9.73	11,381,048 4.78	5,135,365 2.96
Child benefit	12,090,060 3.76	11,161,682 3.51	9,912,588 3.47	9,377,938 3.93	8,427,631 4.86
Immediate emergency aid	19,580,920 6.10	8,813,540 2.78	8,633,847 3.02	3,180,513 1.33	358,973 0.21
Benefit to cover the needs of a child	4,042,563 1.26	4,089,671 1.29	3,445,560 1.21	4,429,805 1.86	3,434,557 1.98
Remuneration of a foster parent	1,714,756 0.53	1,998,679 0.63	1,359,223 0.48	2,149,065 0.90	2,076,559 1.20
Contribution toward the purchase of a car	1,637,807 0.51	1,812,696 0.57	1,715,935 0.60	1,979,258 0.83	1,591,091 0.92
Mobility allowance	1,190,560 0.37	1,092,000 0.34	1,583,300 0.55	1,662,300 0.70	1,489,266 0.86
Maternity benefit	686,000 0.21	662,000 0.21	428,000 0.15	466,000 0.20	353,000 0.20
Benefit when taking a child into care	37,000 0.01	8,000 0.00	8,000 0.00	0 0.00	0 0.00
Benefit when ending foster care	0 0.00	25,000 0.01	0 0.00	25,000 0.01	0 0.00
Funeral benefit	0 0.00	5,000 0.00	0 0.00	10,000 0.00	0 0.00
Total claims	321,227,137 100	317,557,148 100	285,776,466 100	238,329,827 100	173,581,525 100
Basal index	100	98.86	88.96	74.19	54.04
Chain index	100	98.86	89.99	83.40	72.83

(CZK 281,087,687). The third benefit in question, with 32% fewer claims than in the case of childcare allowance, is housing benefit (CZK 227,065,581), again from the system of state social support benefits. Care allowance is another significant claim (aggregate value of more than CZK 100 million over the five-year reference period), with the total size of the claim standing at CZK 152,815,356 for the reference period, as is supplementary housing benefit (claim of CZK 114,030,254). These are therefore the five core benefits whose settlement should come under stricter investigation. For this reason, they will be analysed in more depth.
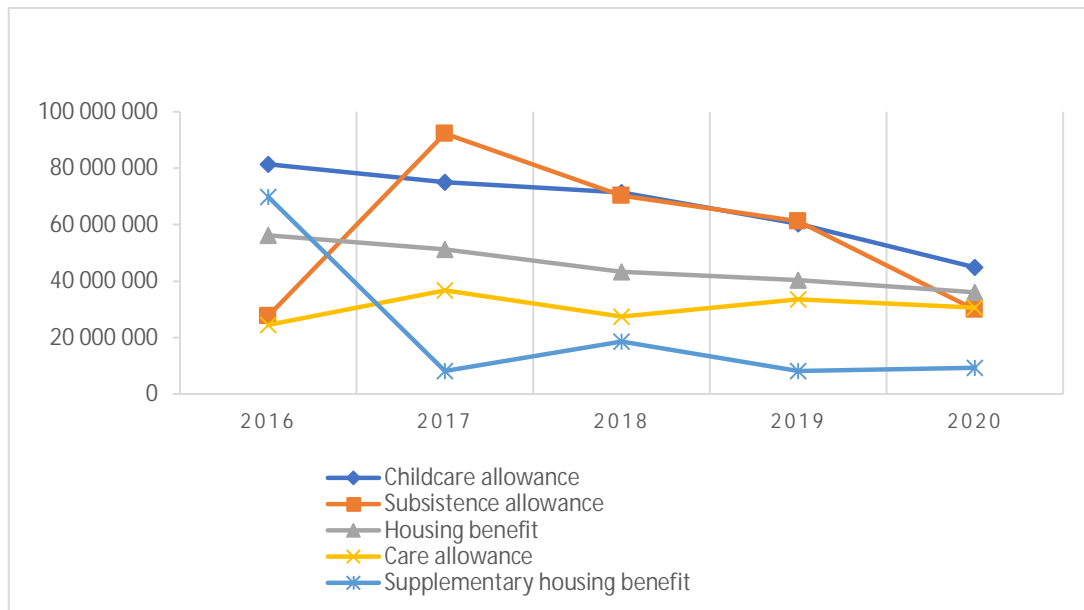
Figure 1. Development of claims in relation to core benefits and development of the total level of unduly drawn benefits during the analysed period (in CZK)

A comparison of the total volume of quantified claims for the individual reference years brings us to the conclusion that undue payments were quantified most in the year 2016, with the total level of undue payments standing at CZK 321,227,137. The years that followed showed a declining trend in terms of the volume of quantified claims, as shown by the results of the basal and chain index. The figure for the final year of the reference period stood at CZK 173,581,525, which is 54% lower than in 2016 (Figure 1).

The aggregate level of unduly drawn benefits shows a continual decline in the reference period (Figure 1). For individual benefits, however (of the five benefits identified as the core benefits), this trend can be identified for childcare allowance and housing benefit. Claims for supplementary housing benefit oscillate considerably in their development (there is always an increase in value after a decrease during the reference period).

3.2. Reasons for the Existence of Claims and the Ways in Which They Are Settled, for Core Benefits

All non-insurance social benefits have the same set limitation period (time-barring), three years from the date of payment. An undue payment must be quantified and must be paid within this period (after identification and proving intent to unduly collect a benefit). This time limit is interrupted if steps are taken to pay the claim (the benefit is deducted, criminal proceedings are ongoing, succession procedure, etc.). After quantifying the undue payment, the Labour Office monitors whether the undue payment is paid by the debtor and how much of the debt remains outstanding. If the debt is not paid (after the payment term for voluntary payment has passed), other methods of recovering the claims are employed, at least for certain benefits - for example, enforcement, permission of instalments (according to the Tax Code of the Czech Republic), or refunding (according to EC No. 883/2004), so that the debt is paid. The Labour office, however, is unable to recover certain claims, but these also need to be properly settled in application programs. These are claims that are passed on to the Customs Authority for recovery. Claims which are written off on account of "uncollectibility" or because the limitation period has passed must also be

settled in the application programs. Below we analyse the reasons for the occurrence of and the methods of settling the five benefits identified as the core benefits in relation to the level of claims.

Childcare allowance is intended for parents who care for the youngest child in the family all day. Expert interviews revealed two reasons for undue drawing. The prevailing reason for an undue payment to occur is the fact that the parents stop caring for the child because the child is taken from them and entrusted to another carer or institute. The second reason is the fact that the mother or the child does not satisfy the condition of having his/her place of residence within the territory of the Czech Republic, and there is no employment tie to the Czech Republic. In such case there is no right to benefit at all. These undue payments often arise because a parent collecting the benefit in the Czech Republic moves, does not have the right to benefit in the new country of residence (does not meet the conditions), and assumes that the Czech Republic will therefore continue to pay him or her the benefit. The Labour Office collects and recovers outstanding claims. Table 2 provides an overview of the method of settling unduly drawn payments in relation to this benefit.

Table 2. Level of unduly drawn "Childcare allowance" benefit and the settlement thereof (in CZK)
(own processing according to Labour Office of the Czech Republic application database, 2021)

Settlement/Year	2016	2017	2018	2019	2020
	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %
claims	81,383,740 100	75,008,585 100	71,409,756 100	60,180,461 100	44,776,499 100
paid	73,361,141 90.14	68,488,509 91.308	64,927,867 90.923	51,936,357 86.30	35,283,300 78.80
remaining to be paid	4,263,085 5.24	4,445,846 5.93	5,328,952 7.46	7,791,606 12.95	9,327,799 20.83
written off	576,972 0.71	306,344 0.41	116,974 0.16	253,067 0.42	131,600 0.29
time-barred	3,182,542 3.91	1,767,886 2.36	1,035,963 1.45	199,431 0.33	33,800 0.08
passed on for recovery	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00

Table 3. Unduly drawn "Subsistence allowance" benefit and the settlement thereof (in CZK)
(own processing according to Labour Office of the Czech Republic application database, 2021)

Settlement/Year	2016	2017	2018	2019	2020
	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %
claims	27,622,567 100	92,149,640 100	70,136,100 100	61,294,767 100	29,884,613 100
paid	15,753,540 57.03	46,321,530 50.27	26,659,280 38.01	44,558,153 72.69	15,739,900 52.67
remaining to be paid	0 0.00	0 0.00	0 0.00	2,378,567 3.88	8,629,433 28.88
written off	0 0.00	0 0.00	6,710,985 9.57	0 0.00	0 0.00
time-barred	0 0.00	1,241,027 1.35	0 0.00	326,053 0.53	0 0.00
passed on for recovery	11,869,027 42.97	44,587,083 48.39	36,765,835 52.67	14,031,994 22.89	5,515,280 18.46

According to experts, the main reason for quantifying undue payment is failure to document crucial incomes (incomes from employment, incomes in accounts, failure to report other people in the household with an income, the sale of a collection, maintenance payments, income from insurance indemnity, the payment of benefits from abroad). Second is a change in the circle of persons assessed together, and third is starting a business. The Labour Office does not recover outstanding claims, instead passing them on to the Customs Authority for recovery.

The number of benefits handed over for recovery for the years 2019 and 2020 might rise given the fact that there are still outstanding claims that fall within the payment term, which if left unpaid will be passed on to the Customs Office.

Housing benefit (Table 4) is intended for the partial coverage of the costs of housing. It is a recurring benefit that is tested against the family income.

Table 4. Unduly drawn "Housing benefit" and the settlement thereof (in CZK) (own processing according to Labour Office of the Czech Republic application database, 2021)

Settlement/Year	2016	2017	2018	2019	2020
	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %
claims	56,140,189 100	51,158,220 100	43,216,748 100	40,449,985 100	36,100,439 100
paid	41,353,093 73.66	37,163,412 72.64	30,093,946 69.64	26,893,751 66.49	20,735,734 57.44
remaining to be paid	7,160,538 12.75	9,188,198 17.96	10,159,793 23.51	12,447,460 30.77	15,188,487 42.07
written off	1,132,301 2.02	599,757 1.17	175,412 0.41	213,305 0.53	39,886 0.11
time-barred	6,494,257 11.57	4,206,853 8.22	2,787,597 6.45	895,469 2.21	136,332 0.38
passed on for recovery	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00

A great many reasons for the quantification of undue payments were identified for this benefit in expert interviews, with none really prevailing over the others. Failure to document all incomes having an influence on the award and size of the benefit and failure to report the fact that children are no longer dependent are joined by other common reasons for the quantification of undue payment, such as failure to announce the expiration of a contract of lease, the client submitting an amended lease contract (landlord-tenant relationship extended by the client), or payment of the costs of housing (the client does not pay the costs, but rewrites or otherwise modifies confirmation of having paid costs). Local investigations were initiated in 2020, the aim being to identify whether the housing for which a benefit application has been submitted is actually occupied by the circle of jointly assessed persons specified in the application and whether the actual incomes of all persons living together have therefore been documented. The Labour Office recovers outstanding claims within the payment term.

The largest volume of claims was quantified in 2016 (Table 4). The number of claims then gradually decreased in subsequent years. The recovery rate of claims also showed a declining trend during the reference period, while on the contrary undue payments which are as yet outstanding showed a rising trend, meaning that the recovery rate might be higher once these

have been paid. The highest volume of time-barred claims came in 2016, at 11.57% (Table 4). The number of time-barred claims fell in the years that followed, but the number of as yet unpaid claims means that this figure need not be final.

Care allowance (Table 5) is a recurring benefit intended for persons who need the assistance of another person because they are unable to carry out normal life activities as a result of their medical condition.

Table 5. Unduly drawn "Care allowance" and the settlement thereof (in CZK) (own processing according to Labour Office of the Czech Republic application database, 2021)

Settlement/Year	2016	2017	2018	2019	2020
	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %
claims	24,450,456 100	36,675,684 100	27,506,764 100	33,619,380 100	30,563,072 100
paid	17,529,696 71.69	26,294,545 71.70	19,720,911 71.70	22,504,040 66.94	20,458,218 66.94
remaining to be paid	581,559 2.38	260,985 0.71	654,257 2.38	3,998,238 11.89	3,634,762 11.89
written off	79,592 0.33	119,388 0.33	89,541 0.33	109,439 0.33	99,490 0.33
time-barred	1,365,654 5.59	2,659,833 7.25	1,536,358 5.59	1,877,772 5.59	1,138,043 3.72
passed on for recovery	4,893,955 20.02	7,340,933 20.02	5,505,697 20.02	5,129,891 15.26	5,232,559 17.12

Experts contend that undue payments arise for two reasons, each as common as the other. The first is the situation in which such persons die and the other, if the person is provided medical care during hospitalisation for an entire calendar month, that the carer fails to report this to the Labour Office within the statutory time limit. The Labour Office may collect undue payments relating to benefits but cannot recover them. Claims that are not paid within the payment term are transferred to the Customs Authority of the Czech Republic for recovery.

Table 6. Unduly drawn "Supplementary housing benefit" and the settlement thereof (in CZK) (own processing according to Labour Office of the Czech Republic application database, 2021)

Settlement/Year	2016	2017	2018	2019	2020
	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %	CZK/ in %
claims	69,798,667 100	8,108,307 100	18,608,513 100	8,124,307 100	9,390,460 100
paid	56,985,847 81.64	5,411,280 66.74	11,132,333 59.82	5,376,307 66.18	7,660,147 81.57
remaining to be paid	0 0.00	0 0.00	0 0.00	0 0.00	520,156 5.54
written off	0 0.00	0 0.00	4,813,127 25.87	0 0.00	0 0.00
time-barred	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00
passed on for recovery	12,812,820 18.36	2,697,027 33.26	2,663,053 14.31	2,748,000 33.82	1,210,157 12.89

Supplementary housing benefit (Table 6) is intended for people who, despite living as economical a way of life as possible, are unable to pay legitimate costs for housing from their own resources. Legitimate costs include rent, payment for the necessary use of energy, and basic services associated with the use of housing. For the benefit to be paid, the person must be in a situation of material distress and collect subsistence allowance.

According to the results of expert interviews, undue payments arise for multiple reasons (ordered from most frequent to least frequent): failure to document all applicable incomes in the family, failure to specify all persons living in the household in the application (and failure to document their incomes), leaving housing or lodgings and failing to report this fact (in other words, not using the benefit for the purpose for which it was provided). The Labour Office collects undue payments on benefit but claims past their payment term are passed on to the Customs Authority.

The highest volume of quantified claims for supplementary housing benefit came in 2016 (Table 6). The volume of quantified undue payments on this benefit in subsequent years dropped dramatically, by 88% in 2017 and 2019, by 73% in 2018 (the lowest decrease), and by 87% in comparison with 2016 in 2020.

3.3. Evaluation of the Method of Settling All Analysed Benefits

The analysis of the methods of settlement provided above was also carried out for all sixteen non-insurance social benefits in the Czech Republic. It was ascertained, by comparing the total volume of quantified claims and the total volume of paid claims, that the recovery rate of claims is 71%. 9.4% of quantified claims are still outstanding, however, meaning that the recovery rate might rise further. The largest volume of claims was paid in 2016, with the volume of paid claims dropping in subsequent years, even taking account of claims which have not yet been paid but could have been. A recovery rate of 100 per cent was only shown for funeral benefit and benefit when ending foster care. The fact that generally low claims were quantified for these benefits cannot, however, unambiguously lead to the conclusion that this is the reason for the full payment of claims, since a similar volume of claims was quantified for benefit when taking a child into care and that was only paid back in 95.8% of cases, with 4.2% remaining unpaid, whereby if this remaining sum is not paid, it might be settled by write-off, time-barring, or transfer to the Customs Authority for recovery.

One way of settling quantified, but outstanding claims is writing-off claims (most commonly as a result of uncollectibility). By comparing the total volume of quantified claims for the reference period and the total volume of claims that were written off (following the internal administrative process set by the Labour Office), a total of CZK 41,454,625 was written off for the reference period, meaning 3.1% of claims. The highest volume of claims was written off in 2018 – 1.5%, CZK 19,883,643. The number of written-off claims in other years did not exceed one per cent. An analysis of individual benefits showed that, in total, the highest volume of write-offs of quantified claims was found for contributions toward a special aid, at 26.3% and a value of CZK 23,691,754, meaning that the financial value of write-offs is the highest here of all write-offs for individual benefits. It was ascertained from inside

sources that the cause lies in the fact that individual undue payments quantified for this benefit are financially high because the awarded benefit itself is high (up to CZK 400,000). If the debtors do not pay the debt, it is recovered by the Labour Office, which, in the case of lack of means, the non-existence of a sanctionable account or salary, or the enforcement of the sanctionable benefit, does not have many recovery options available to it. The lowest percentage of write-offs was identified for care allowance and the lowest write-offs expressed as a value for mobility allowance. No write-offs were made for funeral benefit and benefit when ending foster care, since they were fully paid, or for benefit when taking a child into care, maternity benefit, and immediate emergency aid, since it is still likely that these will be paid or settled in some other way.

Another form of settling outstanding claims is time-barring. Comparison of the total volume of quantified claims for the reference period and the total volume of claims which were time-barred revealed that a total of 2.7% of total claims were settled in this way during the whole of the reference period. The highest financial volume of time-barred benefits was shown for housing benefit, followed (from the financial and the percentage perspective) by care allowance. By contrast, the lowest percentage of time-barred benefits was shown for subsistence allowance. There was no settlement by time-barring for funeral benefit, benefit when ending foster care, benefit when taking a child into care, and supplementary housing benefit.

By comparing the total volume of quantified claims and the total volume of claims transferred to the Customs Authority for recovery, we discovered that 13.8% of claims were passed on for recovery, accounting for CZK 183,719,400. When evaluating the total number of claims transferred for recovery, however, it is important to be aware that the Labour Office does not transfer certain benefits to the Customs Authority for recovery, specifically-speaking, benefits according to the Act on State Social Support and according to the Act on the Provision of Benefits to Disabled People. The highest volume of claims transferred for recovery was found for subsistence allowance (40.1%), which is at the same time the benefit with the second highest number of quantified claims. In second place was immediate emergency aid (30.9%), which also falls within the system of benefits provided to people in material distress. By contrast, the lowest percentage in terms of the volume of quantified claims (a mere 18.4%) was identified for care allowance, this although it shows the third highest amount transferred for recovery.

4. Discussion

The results of the case study carried out in the Czech Republic confirm the conclusions drawn by Halla and Schneider (2014) and Halla et al. (2010), in that it was proven that there was a noticeable, progressive, and continual decline in the aggregate level of unduly drawn benefits, testifying to the ability of labour offices to recover undue payments more effectively. The reasons for undue payments, ascertained from expert interviews at Labour offices in individual regions of the Czech Republic, partly correlate to the reasons stated by Tunley (2011), although the level of greed is debatable, or differs depending on the social situation in which the benefit recipient finds him/herself.

5. Conclusions

The battle against social security benefit fraud has become a priority in a number of countries given that expenditure on social benefits accounts for a significant portion of public expenditure as a whole. The main problem is detecting fraud in social security systems. This article has sufficiently proven that abuse of non-insurance social benefits by clients is a serious problem, whereby the most conclusive evidence for this comes from the values of the claims quantified in undue payment decisions. The total value of unduly paid benefits during the reference period was more than CZK 1.3 billion, which is an amount that could evidently have contributed to the budget of the Czech Republic (in particular the major deficit budget of the final year of the reference period).

The five most significant benefits, with the highest claims in terms of value, were identified in a case study of non-insurance social benefits: childcare allowance, subsistence allowance, housing benefit, care allowance, and supplementary housing benefit. The reasons for claims were identified for each of these five core claims in expert interviews, in which experts ordered those reasons according to the frequency at which they occur based on their practical experience.

It was ascertained, by comparing the total volume of quantified claims and the total volume of paid claims, that the recovery rate of claims is 71%. 9.4% of quantified claims are still outstanding, however, meaning that the recovery rate might rise further. The article also analyses the size of the claims that are thereafter enforced for the purpose of increasing the recovery rate of money for the national budget and documents the significant level of claims that are written off or time-barred.

The progressive and continual decline in the aggregate level of unduly drawn benefits within the analysed period is clear from a graphic depiction of development, testifying to the opportunities that authorities have to recover benefits more effectively, and in doing so take care of taxpayers' money in the Czech Republic (current or future).

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Income Inequality of Population in European Countries During COVID-19

Erika LAPINOVA

Matej Bel University, Banska Bystrica, Slovakia; erika.lapinova@umb.sk

Abstract: The COVID-19 pandemic has serious economic and social consequences, including impacts on the socio-economic situation of households. In our contribution, we want to focus on the effects of the pandemic on the income inequality of the population of European countries and its causes. In the theoretical part, we present several studies that were created on the given issue, mainly at the international, but also at the national level from Slovakia, Czechia and other national states. We also clarify the difference in the results that the studies bring. In the analytical part, using indicators from the EU SILC surveys from the Eurostat database, we describe the development of the level and rate of income inequality in European countries in 2019-2021 (the last available data), which is last pre-pandemic and two pandemic years. We describe income inequality measured by the Gini coefficient and by median income. We describe the income level according to average income values. For comparison, we present data on income in euros vs. in PPS. The effects of the pandemic on the income inequality of European nations are very diverse, but common factors across European countries that had an impact on the development can be specified. We summarize these in the work. In conclusion, we point out, among other things, the importance of investigating the given issue, especially in the context of crisis developments or other turbulent changes in the European economic environment that await us prospectively.

Keywords: income inequality; Gini; equivalised disposable income; mean and median values; Europe

JEL Classification: D31; D33

1. Introduction

The COVID-19 pandemic is not only a health crisis, but it has also significantly affected the economic and social situation of countries and their populations. There are many researches devoted to various aspects of this pandemic, health, socio-economic and their interconnection and connections between them. In our contribution, we focus on the investigation of the impact of the COVID-19 pandemic on the income level and on the inequality of the income distribution of the population in the European area during pandemic years (later data from harmonized survey EU SILC are not available). We process knowledge from already existing research and studies on the given topic and systematize their results. In the analytical part of the work, we describe and compare the state and development in the years 2019 to 2021, using available data from harmonized European surveys on income and living conditions of the EU SILC, which are in the Eurostat database.

The available knowledge about the development of income inequality of the population in the times of COVID-19 is very diverse, sometimes even contradictory. How to explain it? This is due to the source of data with which the researches and studies based on them work, but also the way of analyzing and processing this data, the indicators used (considering their specificities and limitations), the way of their interpretation. The mutual comparability of research results is also limited due to the different socio-economic and demographic composition of individual countries, groups of countries or regions within countries (if we are talking about interregional differences within one country, which are also worth paying attention to). As for the factors affecting the income of the population during the COVID-19 and transmission channels, we have summarized them into the following groups:

1. changes caused by COVID-19 in the labor market (white vs. blue collars, high-educated – low educated, precarious work and some types of flexible working hours and working relationships, illegal workers), job loss, reduction of working hours with reduction of work income, etc. (for more details, see The territorial impact of COVID-19: Managing the crisis across levels of government, OECD, 2020),

2. the structure of the economy and employment in individual branches and sectors of the economy, including the types of professions performed (this also implies the nature of work and the ability to perform work during the lock down), (for more details, see the maps of the EU regions from the point of view of their exposure and sensitivity to the economic crisis due to covid-19 in: *Potential impacts of COVID-19 on regions and cities of the EU*, European Union, the Committee of the Regions, 2020),

3. gender-based differences in the labor market during covid-19 (including the need to care for children during lock downs) (Laurimäe, 2022),

4. differences between workers of different ages and their situation on the labor market at the time of COVID-19,

5. differences between workers of different nationalities (foreigners), ethnicity and race on the labor market at the time of COVID-19 (Işık, 2022),

6. digitization and its accessibility for all (especially in the case of online education),

7. social situation, including income, before the pandemic,

8. differences between the rural and urban population,

9. in an international comparison, different types of state restrictions in the time of COVID-19 and measures to help individuals and companies in the time of COVID-19 play a role.

In many studies, it is said that despite the fact that the short-term effects of COVID-19 on income inequality are mostly discussed, the long-term effects caused by COVID-19 are more fundamental/significant (long-term effects on the labor market, on the organization of work/the way work is performed, effects on the young generation, which was disadvantaged at the time of COVID-19, in terms of education or the labor market, impacts on low-skilled and low-income groups of the population, etc.).

Below in the diagram, the factors of the impact of COVID-19 on income inequality according to the above modified Eurofound study (2023) are summarized as follows:
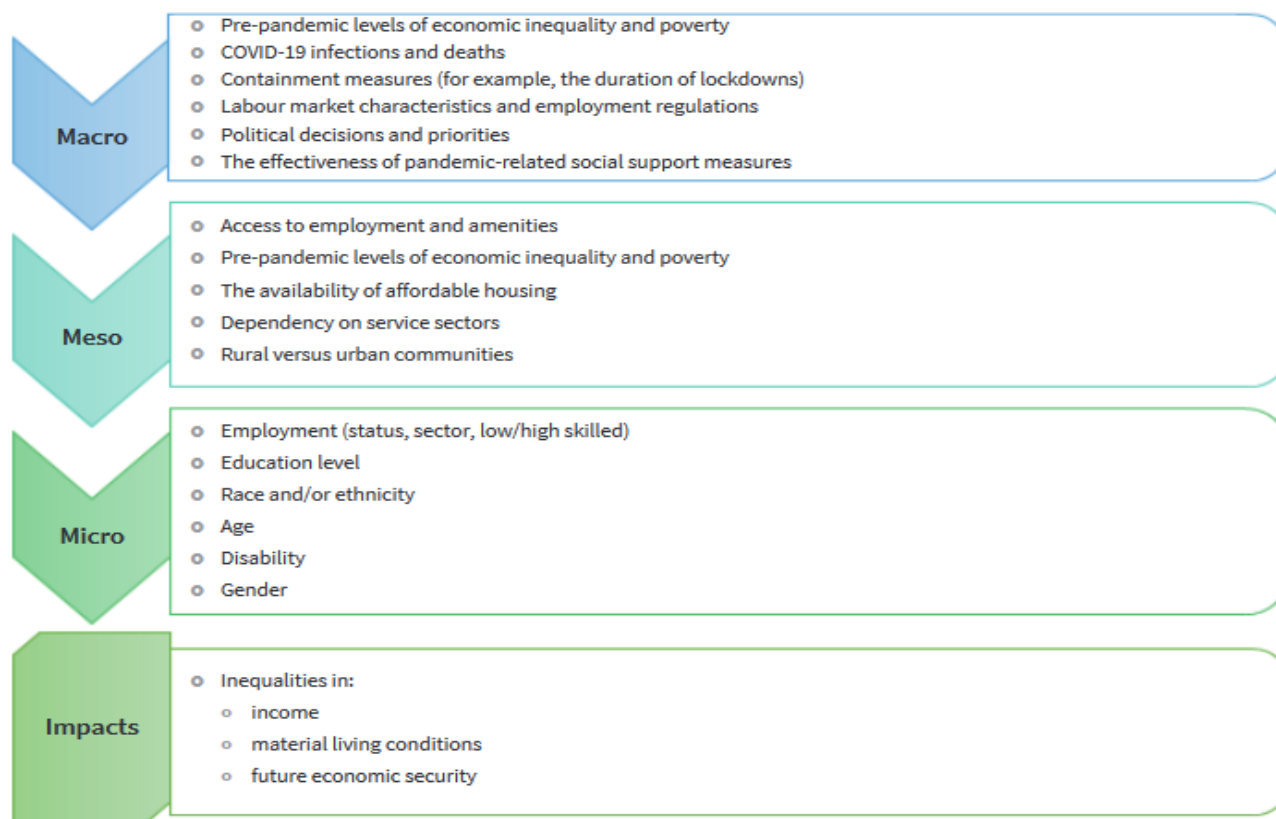
Figure 1. Macro-, meso- and microlevel factors in income inequality during the COVID-19 pandemic (Eurofound, 2023)

In Slovakia, several institutions and authors addressed the issue of the impact of COVID-19 on the income of the population. We will mention two institutions here: National Bank of Slovakia (NBS) and The Council for Budget Responsibility. NBS using knowledge from the last wave of HFCS (Household Finance and Consumption Survey, which is harmonized European survey of European Central Bank) detection. From the analysis of the obtained data on income inequality in the first mentioned study, it emerged that: *The main channel through which the pandemic affected households' economic and financial situation was the labour market. People faced shocks mainly in the form of job loss, business closure or temporary wage reduction. Wages were reduced for various reasons. Falling business sales may have translated into employees receiving less than 100% of their salary or into a decline in self-employment income. At the same time, wage reductions may or may not have been associated with a reduction in working hours. Hours may have been reduced by the employers (in response, for example, to reduced business operation) or for personal reasons (employees asking for reduced hours or leave to take care of children or relatives or because of their own illness or health problems).*

Based on analysis of real data from the EU SILC survey, with which the National Bank of Slovakia study worked: a quarter of households experienced a reduction in income. Since income reduction is highly correlated with a negative working life situation, this proportion was higher for specific subgroups mentioned above: self-employed households (48%), households aged 16-34 (38%) and 35-44 (35%), and households working in contact intensive services (36%) and manufacturing (33%).

The Council for Budget Responsibility (The Council for Budget Responsibility was formed in 2012 as an independent body set up to monitor and evaluate the fiscal performance of the Slovak Republic) analyzed the impact of the pandemic on the income of households in Slovakia categorized according to various characteristics, while working with anonymous data on household income from the Social Insurance Company. From its report we select: *In the most critical month of May 2020, the income of workers in Slovakia decreased year-on-year by 43%, which is a significant increase compared to 2019, when the reduction in income affected 26% of workers. Despite the negative economic development, the average disposable income of workers rose compared to last year. The shortfall in work income was compensated mainly by sickness benefits. The shortfall in work income was compensated to a higher extent for women than for men. From the point of view of age categories, the incomes of persons aged 26 to 40 were compensated the most. The pandemic did not affect the disposable income of persons outside the labor market. Their income increased by 5.4%. The disposable income of old-age pensioners increased by 1.4% in 2020.*

Unlike domestic sources (or foreign sources that map developments within one country), which mostly draw on real data on the income of the population at the time of the pandemic, international studies (due to the two- to three-year delay related to obtaining data from international harmonized surveys such as EU SICL or LFS) worked only with expert estimates or with simulations on microdata from the years before the pandemic. However, there are exceptions, for example, the COME-HERE database, surveyed by University of Luxembourg since the beginning of the pandemic.

If we would like to map Czech sources of literature dedicated to research on the effects of COVID-19 on income inequality: in the Czech Republic, the impact of COVID-19 on income inequality, especially with an emphasis on the regional dimension of this issue, is addressed, for example, in a study by the Research Institute of Labour and Social Sciences of Červenka, Beran and Bílková (2022) or in a study by Luxemburg Stiftung of Bittner (2020). The first of the mentioned studies decomposes and analyzes regional income inequality in the Czech Republic after the start of COVID-19 pandemic. Significant rise of wage concentration was identified; however, it was overruled by the effect of other income sources, resulting in decline on the total Gini index in 2020. This outcome can be attributed to activity of the public sector, however not to the social security system. The decline of inequality was achieved through discretionary policy (entrepreneurial compensation bonuses). To decrease the inequality by existing social security scheme, Czech government could augment assistance in material need, child allowance, foster care benefit or housing allowance.

The impact of COVID-19 on income inequalities is addressed by all major international institutions, such as the World Bank, OECD, European Union Institutions. The World inequality report 2022 maps income inequality and its evolution up to 2020 (Chancel et al., 2022, p. 55). From foreign and international research and studies devoted to the issue of the impacts of COVID-19 on income inequality, we will mention, for example, the works: Dauderstädt (2021a, 2021b, 2022a, 2022b), Ferreira (2021), Almeida et al. (2021), Astarita and Alcidi (2022), Waldenström (2021), Clark, d'Ambrosio, and Lepinteur (2021), Narayan et al. (2022), Darvas (2021), Palomino, Rodríguez, and Sebastian (2020). Large literature review on the issue is also provided by Stantcheva (2022), including a complex of economic-policy measures to prevent

unwanted inequalities. On page 7 in her paper we also find an overview of research on the development of Gini in the time of COVID-19 by various authors (including an indication of data sources and how to work with them in individual research studies).

Almeida et al. (2021) analysed the impact of the COVID-19 crisis on EU households´ income. Additionally, and effect of discretionary fiscal policy measures taken by the EU Member States. They found that the COVID-19 pandemic is likely to affect significantly households' disposable income in the EU, with lower income households being more severely hit. Their results indicated that discretionary fiscal policy measures play a significant cushioning role, reducing the size of the income loss (from −9.3% to −4.3% for the average equivalised disposable income). Results of their study also show that the impact of the COVID-19 crisis was highly regressive, with the lowest deciles of the income distribution being more severely hit, and lead to a significant increase in poverty.

Authors used EUROMOD, the EU microsimulation model, to simulate and compare households' income, inequality and poverty indexes under each macroeconomic scenario and to estimate the overall impact of the crisis and the cushioning effect of discretionary fiscal measures. EUROMOD is a static tax-benefit microsimulation model covering in a comparable way all the EU Member States. The model enables consistent EU-wide tax-benefit and distributional analyses. Authors in this way overcome the methodological challenge posed by the lack of up-to-date survey data by reweighting the microdata underlying EUROMOD based on the European Union Statistics on Income and Living Conditions (EU-SILC).
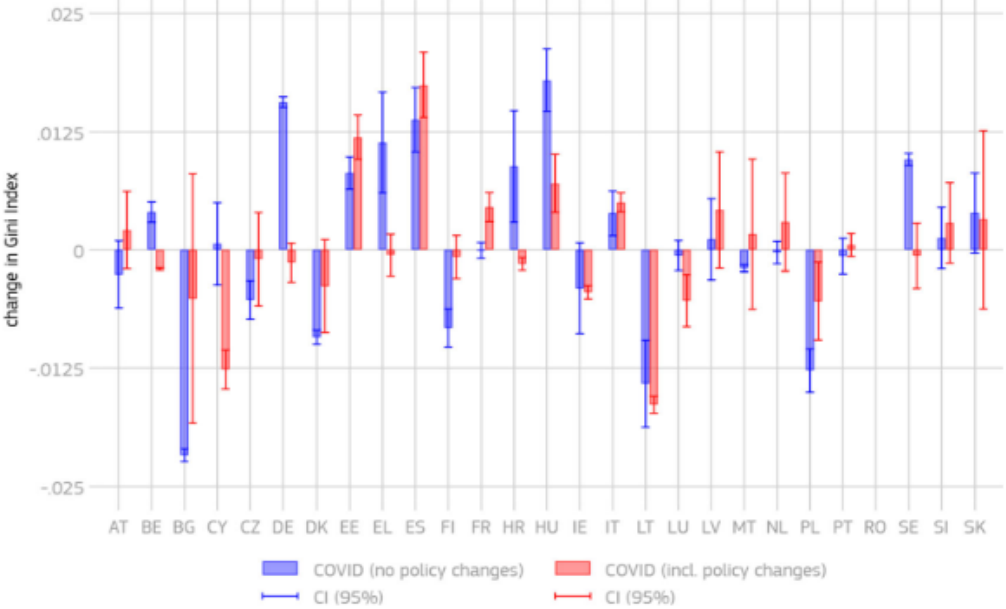
Figure 2. Impact of the COVID-19 crisis on inequality (Gini index) in EU countries, based on calculations using EUROMOD I2.0+ (Almeida et al., 2021)

On the evolution of inequality, Eurofound's document (Economic and social inequalities in Europe in the aftermath of the COVID-19 pandemic, 2023) states: *In 2020, the income quintile share ratio in the EU stood at 4.9, meaning that the total income held by the richest fifth of the population was 4.9 times greater than the total income held by the poorest fifth. This marks a decrease compared with 2019 (when the ratio was 5.0). While this seems to suggest that the pandemic has not*

significantly affected the trend of decreasing income inequality, it is important to note that COVID-19 interrupted the data collection activities on which these results are based, and some countries (e.g. Germany) introduced changes to the methodology. This means that 2020 data may not always be directly comparable to the data of previous years.

The trends in income inequality over time were also observed by estimating the Gini coefficient (Figure 2). In 2020, the EU27 Gini coefficient was 0.30. For reference, the highest Gini coefficient recorded globally was 0.62 in South Africa (2017, latest data; OECD, 2022) and the lowest Gini coefficient recorded was 0.21 in Slovakia (2020 data; Eurostat [ilc_di12]). The EU27 Gini coefficient was relatively stable during 2010–2020, but differences were measured at country level. For example, in Bulgaria, inequality steadily grew from 2010 to 2020 (the Gini coefficient increased from 0.3 to 0.4). Meanwhile, in Poland, the Gini index decreased from 0.31 in 2010 to 0.27 in 2020. In both countries, income inequality decreased during the pandemic. Similarly, to the income quintile share ratio, these results should be interpreted with caution owing to breaks in the time series (Figure 3).
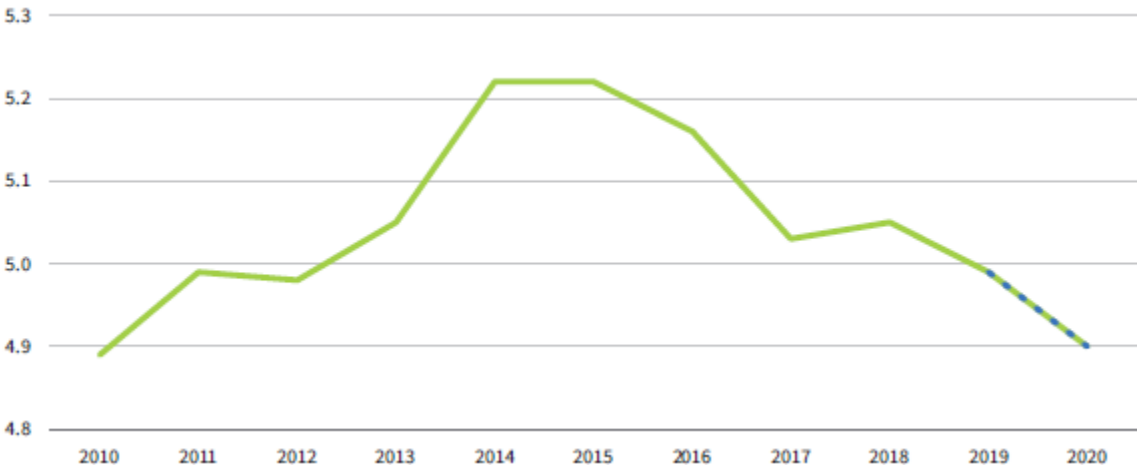
Figure 3. Income quintile share ratio (S80/S20) for equalized disposable income in EU27, with data from database EU SILC from Eurostat (Eurofound, 2023)

2. Methodology

The data source in our analysis of income level and income inequality distribution in European countries is the harmonized European survey on income and living conditions (EU SILC). For comparison, we have selected data from the last three years for which data from the EU SILC surveys are available (these are EU SILC surveys 2020, 2021 and 2022, the reference years of which are 2019, 2020 and 2021).

Using the tools of descriptive statistics, we summarize basic information about the distribution of equalized net income in the European countries, measured by the Gini coefficient, and subsequently also using descriptive statistics of equalized net incomes levels in Euros and in PPS (using the values of median and average equalized net incomes).

3. Results

Figure 4 shows the development of the inequality of the distribution of equivalent disposable income measured by the Gini coefficient. Fluctuating development of the value of the Gini coefficient prevails in European countries in the monitored years 2019-2021. While
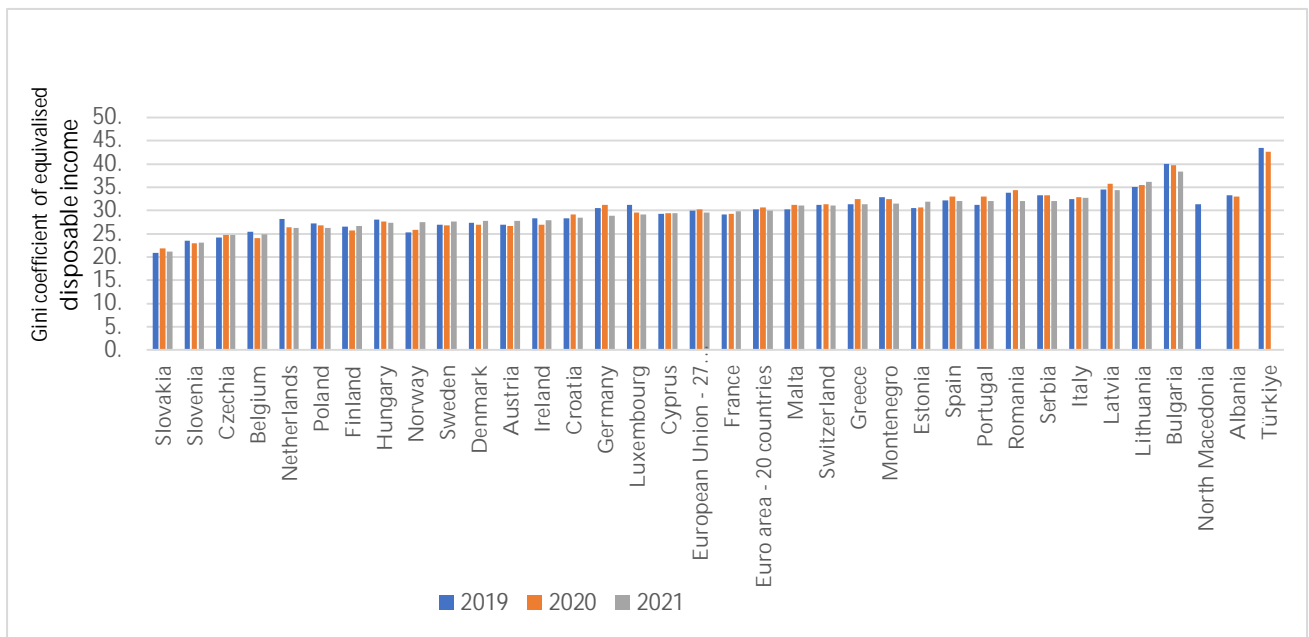
Figure 4. Gini coefficient of equivalised disposable income in EU countries in the years 2019-2021 (Eurostat, EU SILC Database)

the value of the Gini coefficient for all EU countries or the Eurozone is very balanced in the monitored period, in the case of individual countries we already observe larger inter-annual differences in the value of the Gini coefficient. In some European countries the value of the coefficient increased in the first year of the pandemic, and decreased in the second year (Germany, Greece, Spain, Croatia, Italy, Cyprus, Latvia, Malta, Portugal, Romania, Slovakia or Switzerland), in another group (Belgium, Denmark, Ireland, Slovenia, Finland, Sweden) is recorded a decrease in the Gini value in the first year of the pandemic, but its value increased in the second. France and Norway are among the countries with an increasing value of the Gini coefficient during the entire monitored period, on the other hand, Luxembourg, Hungary, Poland and Montenegro recorded decreasing values of the Gini coefficient during the monitored period.

Figure 5 contains basic descriptive statistics of income inequality in European countries measured by the Gini coefficient of equivalised disposable income for the year 2021. The median value of the Gini coefficient of 29.1 divides the set of countries studied into two halves, i.e. j. half of the countries from the studied set had Gini coefficient values equal to or higher than the mentioned value in 2021, the other half of the countries had values equal to or lower. The approximate value of the Gini coefficient was 29.4, minimum 21.2, maximum 38.4. The value of the Gini coefficient at the level of the upper quartile of the distribution was 32, in the case of the lower quartile it was 27.4.

Furthermore, we focused on researching the level of income measured by equivalised net income and its changes in individual countries and in the EU countries and Eurozone as a whole. On the x-axis in Figure 6, countries are ranked in ascending order by the size of this median equivalised net income in 2021 (based on EU SILC 2022 survey data). There is a prevailing trend of income level growth in individual countries between 2019 and 2021. On average, the level of income measured in this way is stable for EU and Eurozone countries.

Norway and Germany are exceptions, in which in the first year of the pandemic the level of average equivalised disposable income measured in euros fell, in the second year in Germany it remained unchanged compared to the previous year, in Norway it increased year-on-year (however, it did not reach the level of average equivalised disposable income in euros before the start of the pandemic).
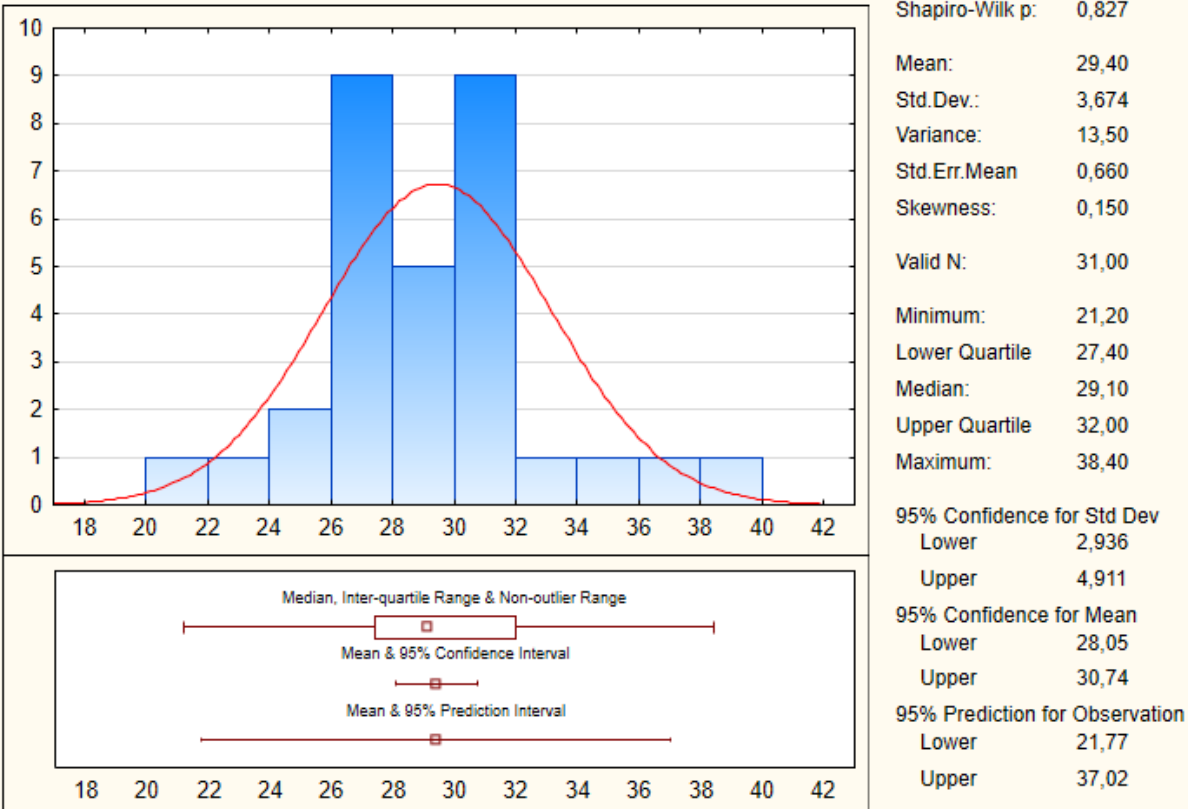
Figure 5. Descriptive statistics of income distribution in 2021 measured by Gini coefficient of equivalised disposable income (summary) in EU (Data source: Eurostat, EU SILC Database; software used: Statistica)
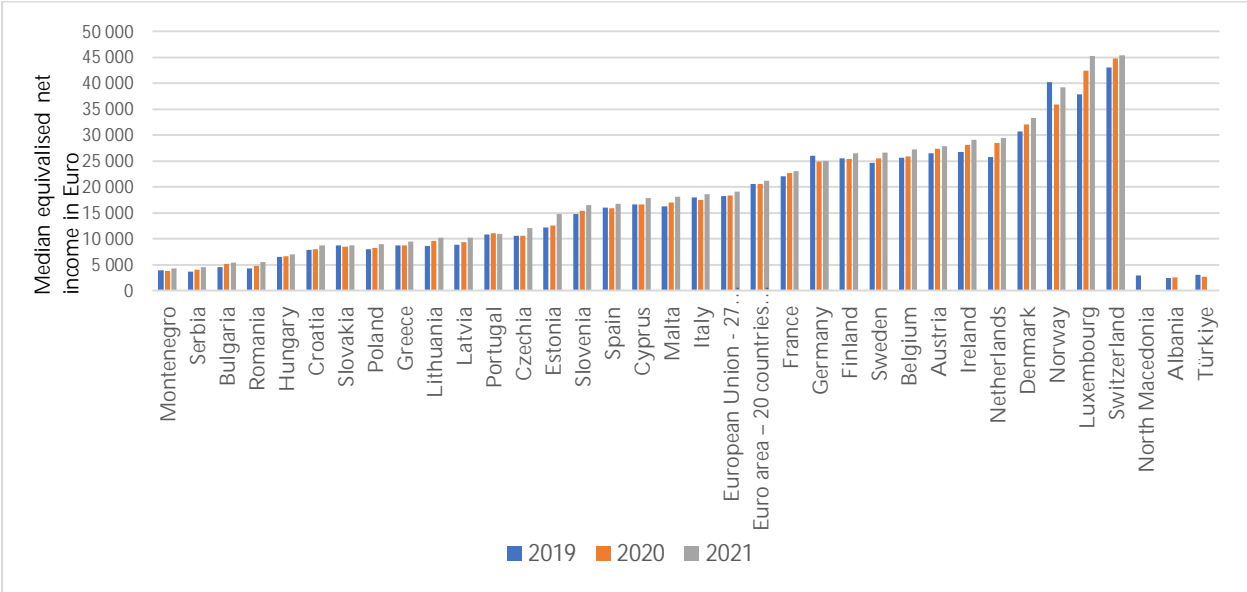
Figure 6. Median equivalised net income in Euro in EU countries in the years 2019-2021 (Eurostat, EU SILC Database)
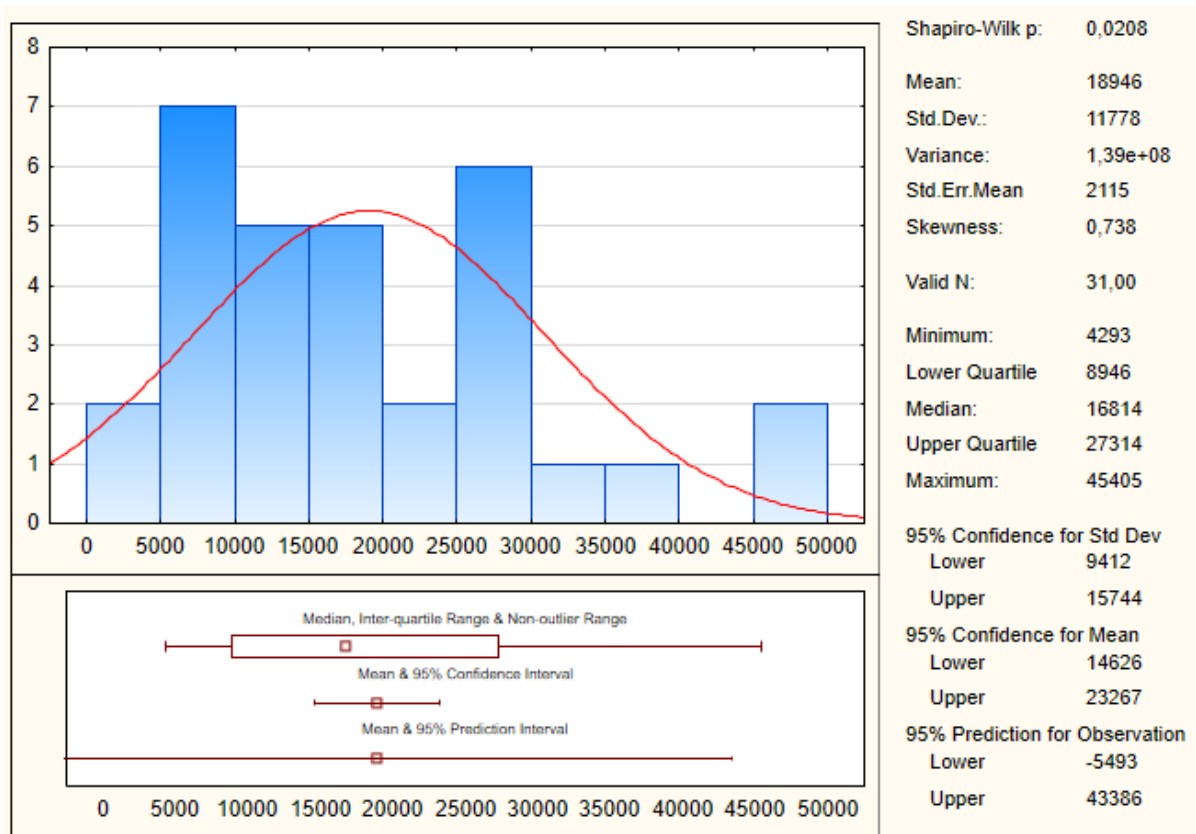
Figure 7. Descriptive statistics of income distribution in the year 2021 measured by median equalized net income in Euro (summary) in EU (Data source: Eurostat, EU SILC Database, software used: Statistica)

Norway, Montenegro, Slovakia and Germany are exceptions to the prevailing growing trend of average equivalised net income in PPS (see Figure 8), because in the case of the first three mentioned countries, we observe a drop in average income in the first year of the pandemic and its subsequent increase in the second year. In Germany, on the other hand, from 2019 to 2021, there was a decrease in the level of income measured by the median equivalised net income in PPS.
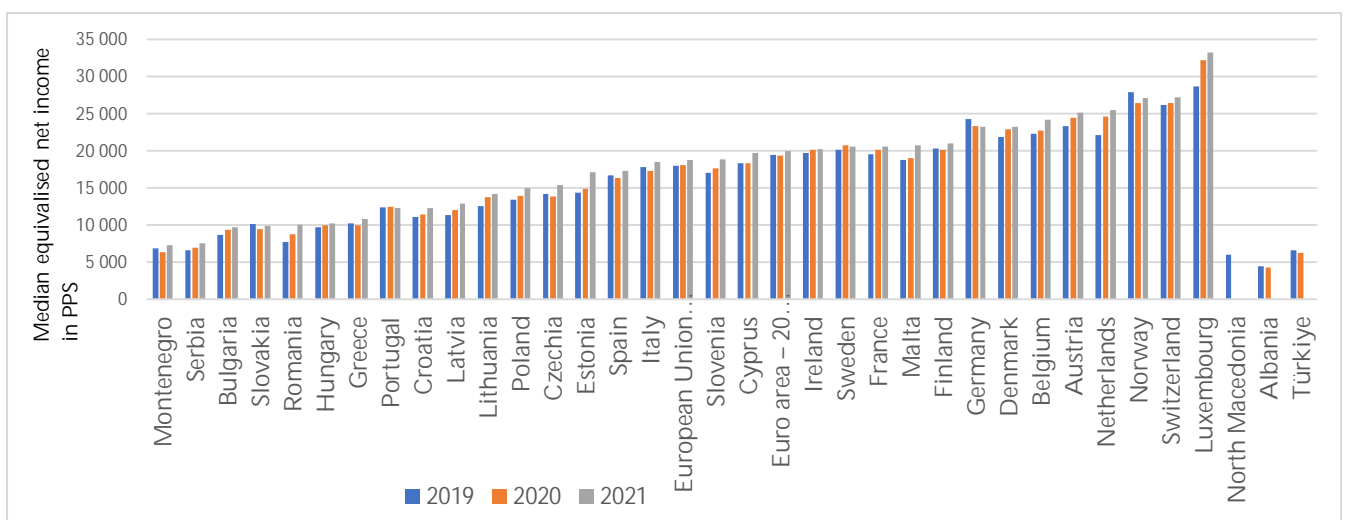
Figure 8. Median equivalised net income in PPS in EU countries in the years 2019-2021 (Eurostat, EU SILC Database)
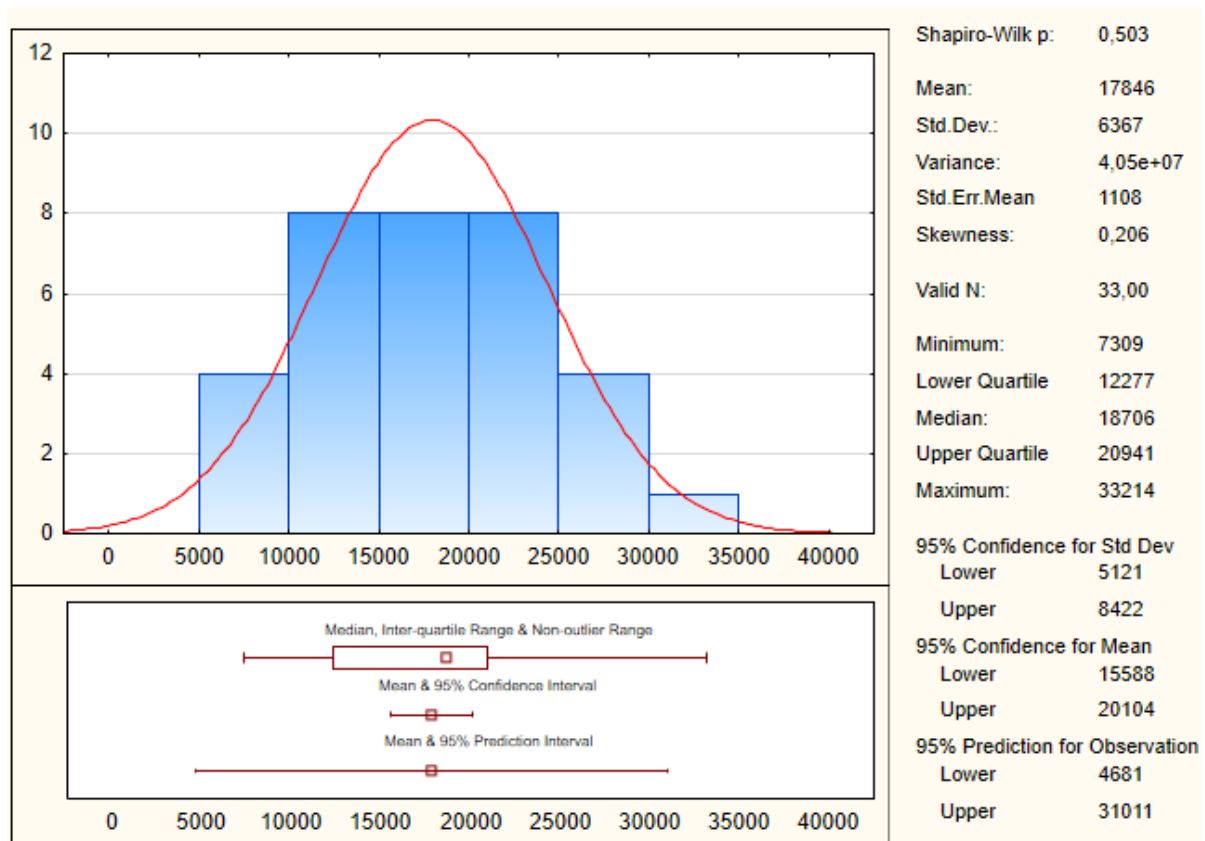
Figure 9. Descriptive statistics of income distribution in the year 2021 measured by median equivalised net income in PPS (summary) in EU (Data source: Eurostat, EU SILC Database, software used: Statistica)

When we consider the average (mean), not the median, equivalised net income values in euro, the range of values for individual countries in ascending order of 2021 values (from EU SILC 2022) looks as shown in the Figure 10. EU countries and Eurozone countries as a whole are somewhere in the middle of the scale. Serbia, Romania, Bulgaria, Hungary and Slovakia are at the top of the list. The Netherlands, Ireland, Denmark, Norway, Luxembourg and Switzerland are at the other end of the scale with the highest values.
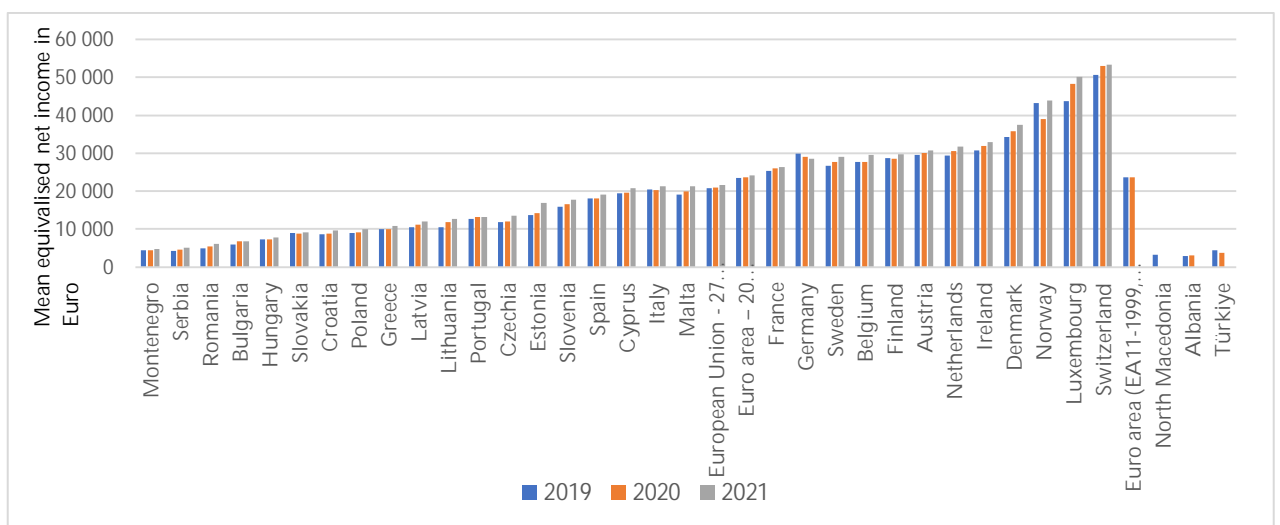
Figure 10. Mean equivalised net income in euro in EU countries in the years 2019-2021 (Eurostat, EU SILC Database)
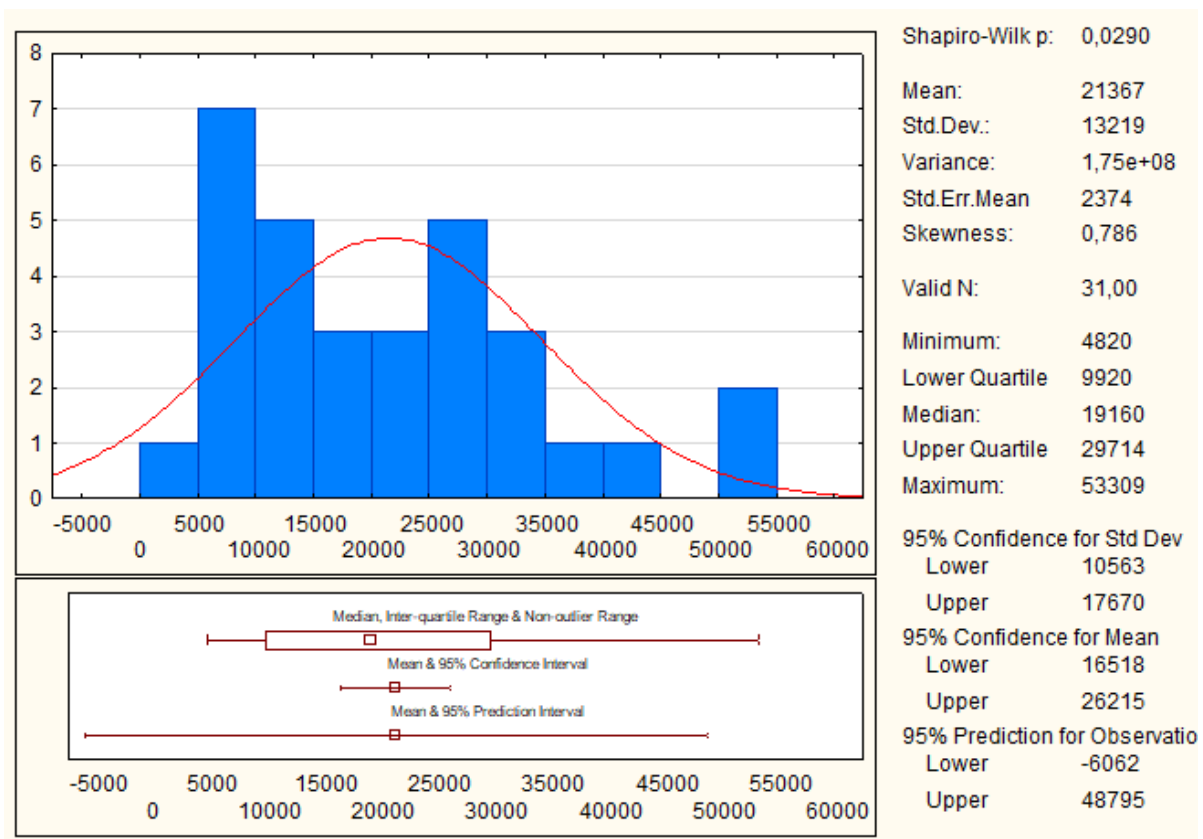
Figure 11. Descriptive statistics of income level in the year 2021 measured by average equivalised net income (in Euro) in EU (summary) (Data source: Eurostat, EU SILC Database, software used: Statistica)

Finally, a look at the ranking of countries by the level of average equivalised net income in PPS (Figure 12). Montenegro, Serbia, Slovakia, Romania, Hungary, Bulgaria and Greece reach the lowest levels of this indicator of the country's income level. The highest values of average equivalised net income in PPS were recorded in 2021 by Belgium, Denmark, Germany, the Netherlands, Austria, Norway, Switzerland and Luxembourg.
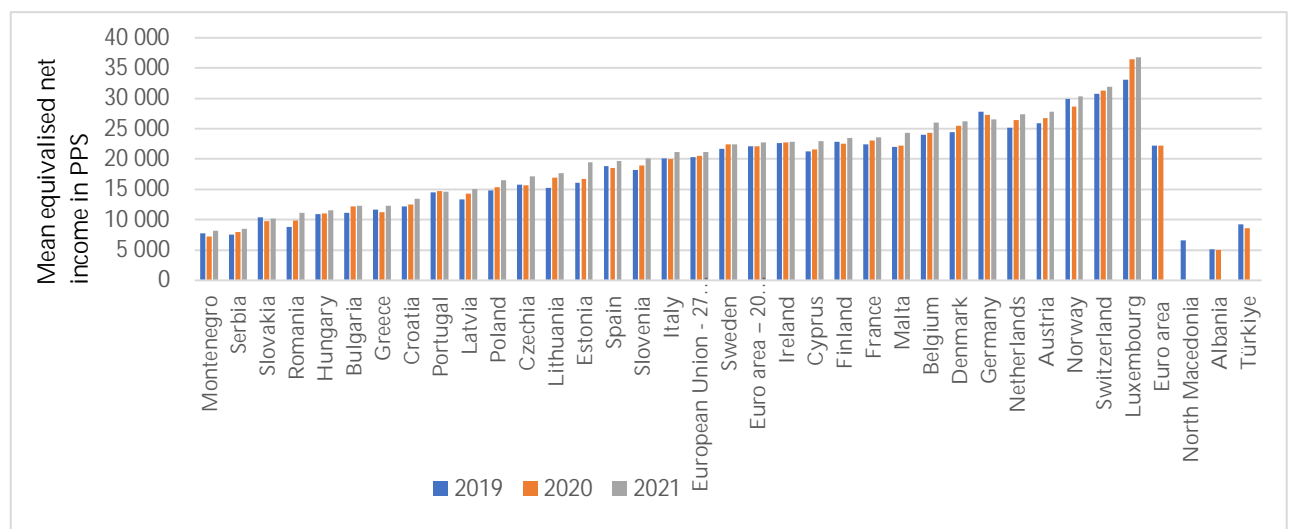
Figure 12. Mean equivalised net income in PPS in EU countries in the years 2019-2021 (Eurostat, EU SILC Database)
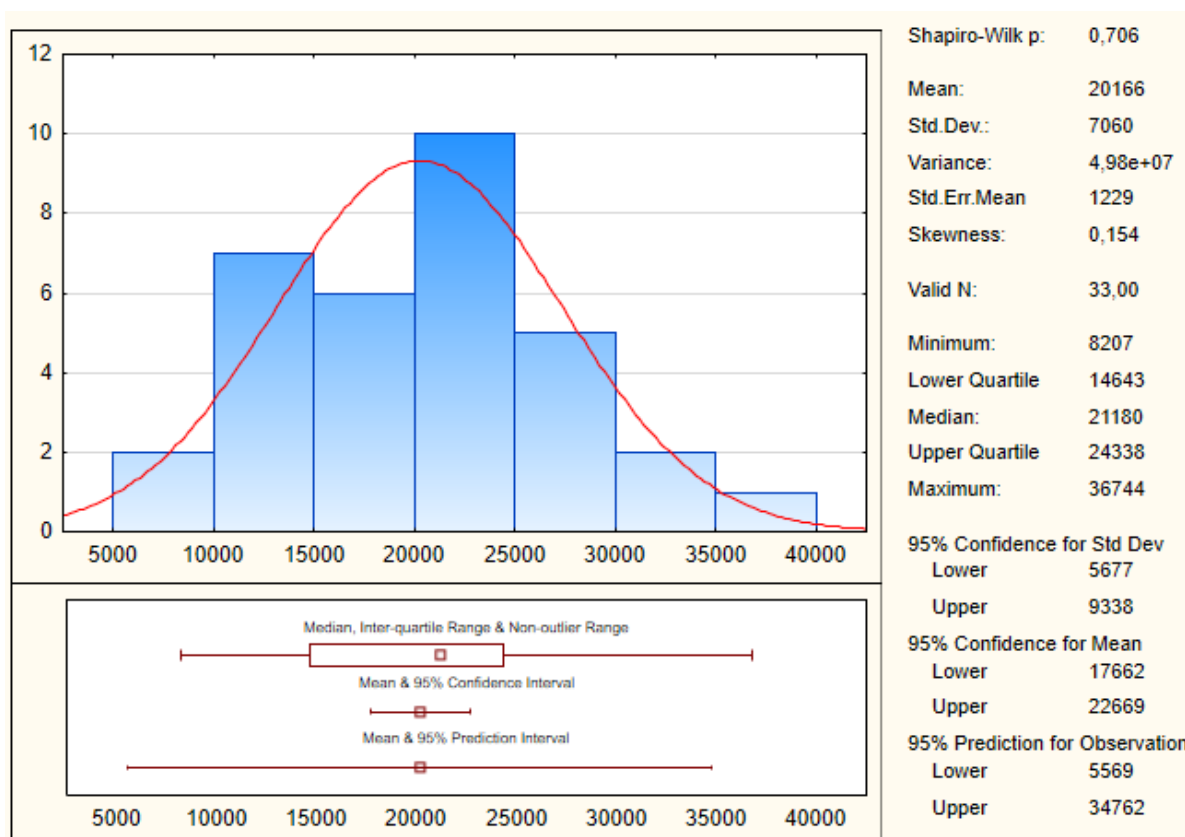
Figure 13. Descriptive statistics of income level in the year 2021 measured by average equivalised net income (in PPS) in EU (summary) (Data source: Eurostat, EU SILC Database, software used: Statistica)

In the case of average values of equivalised net income (both in euros and PPS), the trend of growth or stabilization of the income level prevails in the years 2019-2021. There are also exceptions (Germany with decreasing values of average equivalised net income in PPS, Sweden with decreasing values of average equivalised net income measured in Euros, Luxembourg with a fluctuating development of average equivalised net income measured in euros).

4. Discussion

We want to emphasize that the issue of the impact of COVID-19 on population income inequality has been devoted to a lot of research, many studies and publications. Some pursue an issue internationally; others focus on examining the issue within one or several countries. The diversity of results and conclusions on the intensity and nature of the effects of the pandemic on household incomes depends crucially on the data with which the studies work, their processing methods and the indicators by which their results are interpreted. Taking these facts into account, then comparable conclusions can be reached, some of which are also presented in our paper.

Why address income inequality? After the onset of the pandemic crisis and after recognizing the breadth and depth of its consequences, significantly differentiated within the population, another important reason why the issue is important and worthy of attention not only of researchers and politicians, but also entrepreneurs/employers and other stakeholders.

Other crises such as digitalization, robotization and other innovations affecting the world of work or other innovations in the socio-economic environment in developed and developing countries are also looming on the horizon, and their impacts on income inequality or on socio-economic inequality of the population (more broadly) can be expected to be very similar to those of the socio-economic impacts of the pandemic crisis.

5. Conclusions

Slovakia, as well as the V4 countries, have long been among the European countries with the lowest levels of inequality measured by the Gini coefficient or by average or median income values for the country as a whole. This can also be seen from the graphs in our analysis. The COVID-19 pandemic has not changed somehow significantly interstate ranking of countries in the ranking by the Gini coefficient values, nor has changed the ranking of countries by the income level of countries (measured by the values of average or median incomes). It is not even possible to identify a clear trend in the development of inequalities in European countries at the time of COVID-19. The comparative analysis of the data we carried out nether confirm a clear increasing trend of income inequality during COVID-19 nor decreasing trend of income level.

At this point, however, it is important to note that there are differences within countries in the impacts of COVID-19 on different population groups classified according to the demographic, socio-economic or geographical characteristics (not only urban vs. rural, but also economically developed vs. economically less developed regions, etc.). In our work (especially in its theoretical part), we pay attention to these factors of the impact of the COVID-19 pandemic on population income inequality, and it also appears in other works devoted to the issue, in which is stated that the COVID-19 pandemic did not affect the population as such but had differentiated impacts on different groups according to the categorizations already mentioned above. The differentiated impacts of the COVID-19 pandemic on income inequality of different population groups have been recorded in the world, in Europe and within Slovakia, which is also documented in our paper by mentioning existing research in this area in the world, in Europe and in Slovakia.

Conflict of interest: none.

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Social Media Marketing Communication in Real-Estates Industry: Size and Regional Differences

Jakub LISA* and Pavel BACHMANN

University of Hradec Kralove, Hradec Kralove, Czech Republic; jakub.lisa@uhk.cz; pavel.bachmann@uhk.cz

* Corresponding author: jakub.lisa@uhk.cz

Abstract: In context of the real estate market, the majority of transactions is mediated through intermediaries. Therefore, effective marketing services are essential for achieving optimal results in selling and renting of apartments. While some marketing principles are universal, the real estate sector has specific characteristics and needs an adaptation of strategies for effectively targeting audiences. This study aims to identify the nature of marketing communication within social networks in the real estate sector, including differences of the size of apartments and different regions. Even though each estate is unique, approaches to marketing communication can be heuristically diversified. The study uses content analysis of advertisements for the sale of small and large apartments in premium locations in Prague and in other commonly sought-after locations in the Czech Republic. This involved selected advertised apartments in the period of 2023 to 2024. Individual advertisements were divided into the 4 aforementioned groups and significant factors were descriptively analyzed. It was found that the groups exhibit certain common traits within marketing communication.

Keywords: real estate marketing; social network marketing; customer service; customer value

JEL Classification: M31; M37

1. Introduction

Nowadays, marketing on social networks for the real estate market is extensively used (e.g., Ayodele et al., 2015; Aytekin & Keskin Demirli, 2017; Belniak & Radziszewska-Zielina, 2019; Boudlaie & Moghadam, 2021; Tsakiridou & Karanikolas, 2019). Marketing in the real estate has its own specifics. These are particularly the distinct features and strategies that are tailored to the character and needs of this sector. Key elements of marketing in the real estate industry may include: visual presentation, placement on the website – online presentation, paid advertising on social networks, reputation, and references. Real estate marketing can be characterized as a dynamic system that requires continuous monitoring of trends and adapting strategies in accordance with current market needs. The latest wave of adapting the marketing strategy includes presentation of what? on social networks. Of the total volume of all transactions in the real estate market, approximately half of them are negotiated through a broker. With rising property prices, the amount of broker's commissions also increase, therefore ordinary citizens try to sell the real estate property "on their own", while they do not have sufficient experience with the specifics of the real estate market.

Since March 3, 2020, a new law on real estate brokerage (Law No. 39/2020 Coll.) has been in effect in the Czech Republic, which establishes conditions for providing real estate services

and thereby protects ordinary citizens. Until this time, the real estate brokerage was not regulated by law. The real estate brokerage brings high earnings, therefore there is demand for this profession, especially among individuals envisioning high profits for little work and time, which contributes to the disintegration of the profession. If the possibility of promoting real estates through social networks (where anyone can advertise) has been introduced, then knowledge of marketing strategy provides a significant added value to the success of the sale realized. In the real estate industry, personal relationships, trust between clients and brokers are key elements.

Social networks are gradually becoming a part of people's daily activities in large part of the world. For example, from 2005 to 2015, the representation of social network users in the United States rose from 10% to 76%, among the young group (18-29 years) this number was even 90% in 2015 (Perrin, 2015). At the same time, social networks offer marketing opportunities for individuals, small and medium-sized enterprises (Franco et al., 2016; Ioanid et al., 2018; Nobre & Silva, 2014; Pentina et al., 2012) and large enterprises (Jummani & Shaikh, 2019; Maiorescu et al., 2020). With the increase in e-commerce, the importance of social networks as a suitable platform for promoting real estate items is also emphasized (Dumpe, 2015). For instance, currently, real estates can be advertised directly through the Marketplace application on the social platform Facebook.com (Facebook Marketplace, 2023).

Although the role of social networks in marketing communication used for transactions in the real estate sector is significantly increasing, this topic has not yet received sufficient attention (there is only a limited number of publications in the field). At the same time, existing publications have not specifically addressed factors related to different apartment sizes and regional differences. For this reason, the aim of the study is to identify the key elements of marketing communication on social networks in the real estate sector, including those affected by the size of apartments and regional distinctions.

2. Methodology

2.1. Research Questions

The widespread adoption of e-commerce has led to the implementation of multichannel distribution and omnichannel retailing. At the same time, various kinds of regional disparities have been documented in the Czech context in the past, either directly related to the real estate sector (Hromada, 2023) or informational disparities (Bachmann, 2010).

Multichannel distribution refers to the strategy of reaching customers through multiple, independent channels such as physical stores, online platforms, mobile apps, and social media. The goal is to maximize the reach and provide customers a higher latitude of liberty through broadening the variety of options. Omnichannel retailing has evolved from this multichannel distribution by integrating all channels in order to offer a consistent customer experience across them.

For these reasons, the goal of this work will be achieved through addressing the following research questions (RQ):

RQ1. What online platforms and their nature are used for sales communication in the real estate sector?

RQ2. What differences exist in sales communication throughout the variety of apartment size groups and distinct regions?

2.2. Research Sample

For the purpose of this study, we selected offers for the sale of apartments on the most renown real estate websites. The selected cases included small and large apartments, i.e., in the category of 1+1 (or 1+kk) and 3+1 (or 3+kk) in premium locations in Prague compared to a standard location in a medium-sized city. A total of 150 advertisements for the sale of these apartments were analysed from each category. The data were analysed during 2023 up to the beginning of 2024. Among them premium locations are understood as apartments in Prague in parts of Staré Město, Nové Město, Josefov, Malá Strana, and Hradčany, while standard locations are assessed as average locations, particularly in a medium-sized city without negative aspects such as increased crime. These include broader city centers such as in Mladá Boleslav, Litoměřice, Beroun, Roudnice nad Labem, Hradec Králové, Jihlava, Tábor.

2.3. Evaluation Criteria

In the first step, we accessed the most renown real estate website sreality.cz, then we verified whether any communications of the same objects exist elsewhere. Subsequently, the advertisement was analysed according to the criteria of visual, textual and technical content. The visual content includes such aspects as home staging, visualization of the future state, or photography. The textual content includes such aspects as increasing value for the customer – video tour, information whether it is a direct sale or if the price includes commission, information on market rent in the location, description of the property condition (completeness of information about the property, energy efficiency of the building), etc . The technical content is related for example to the floor area and heating.

2.4. Technical Terminology

Several aforementioned technical terms which are used in the real estate marketing, are necessary to be clarified for the purposes of our analysis. (Wei et al., 2022)

Home staging (HS) – the process of preparing and designing a property to increase its attractiveness to potential buyers or tenants. The aim is to make the property as attractive and appealing as possible to potential buyers or tenants, which typically leads to a faster sale or lease and potentially a higher price. The HS process includes steps and strategies such as adjusting the interior and exterior of the property, removing excess furniture or personal items, using suitable furniture and decorations, lighting and colour scheme, to create an attractive and neutral space that potential buyers or tenants can more easily imagine as their home. HS is commonly used in the real estate market and can be an effective strategy for maximizing property value and accelerating the sale or lease process.

Visualization of the future state (VFS) – the process of creating a visual presentation of a real estate property after its potential reconstruction, representing what it could look like in

the future. This concept is commonly used in marketing when selling the properties, as well as in other sectors, e.g., urbanism, architecture, design, information technologies, and others. These VFS are created to help customers to better understand and visualize what the outcomes of a given project or change might be. VFS provides an idea of what something that does not yet exist might look like. VFS are processed by experts using computer systems.

Photography (Ph) – a way to present a property for sale. Ph are the basis of every offered property. Previously, Ph were created with professional photographic equipment, today also with mobile phone, and the exteriors and surroundings are usually taken with a drone.

Floor area (FA) connected with a ground plan is usually used in context of the real estate construction, referring to the total FA in a given property. It is the area covered by the floor of the property, expressed in square meters. It is the total area of all rooms in the apartment.

Heating method (HM) – a method that achieves an increase in the temperature of the interior space of an apartment. There are many different HMs that vary in the energy source used, in its effectiveness, costs and also by other factors.

3. Results

3.1. The Nature of Online Platforms Used in the Real Estate Industry

The online platforms used for marketing communication in the real estate sector include various media. Real estate agency websites are the key tool for presenting property listings. Nowadays, the basic photo documentation is standard for every advertisement, gradually expanding into the detailed visualization of the entire property including its surroundings. In most cases, photographs are taken especially with wide-angle lenses. Over the last 5 years, photographs are also conventionally taken by drones.

Social platforms such as Facebook or Instagram are not yet standardly used for marketing in the real estate sector in the Czech Republic. So far, less than 20% of all advertisements are published at social networks. The potential of social networks in the real estate sector has not yet been fully discovered. In the Czech Republic, verified real estate servers such as sreality.cz, are still most commonly used. However, it cannot be stated that marketing at social networks does not exist; on the contrary, social networks plays the role of a mediator between the user and the real estate server. The reason is that social networks are now a part of everyday life.

3.2. Differences in Marketing Mommunication – Small Apartments in Lucrative Locations in Prague

These are primarily apartments intended for subsequent rental. Short-term rental platforms such as Airbnb or booking.com usually prevail over long-term rentals. The information about the current renting is rarely provided, only in the case of long-term rentals. In the case of short-term rentals, information on the price for renting an apartment per night is not provided. Mostly, these are apartments in historical brick buildings. In the case that the apartment is not occupied, home staging is usually used. For the apartments which stand before reconstruction, the visualization of the future state is commonly used (see Figure 2). The visualization is well processed, and at first glance, it is not apparent that it is a graphic

created using specialized software. In some cases, a floor plan is included, especially for apartments with complex layouts (see Figure 1). The description of individual apartments is mainly designed to highlight the attractiveness of the location with the possibility of hassle-free subsequent rental. Advertisements often start with phrases like "Profitable investment," "Invest in housing in the heart of Prague," "Unique opportunity to purchase an investment apartment." For advertised apartments in historical buildings, sometimes the history of the building itself is mentioned. Luxurious elements are also cited for the apartments. In case of the apartments in good condition, a recent renovation is often mentioned, while for older apartments, it is usually stated that the property is in good condition. Photographs are taken especially with wide-angle lenses with above-standard brightness. Drones are not used in this category. The description of apartments in this category is extensive. The description usually contains only the positives of the specific property. In most cases, the street where the apartment is located is mentioned. From the attached map, it is then apparent what the conscription number is (in the text, the conscription number is mentioned sporadically). On the other hand, is a rule that the floor on which the apartment is located is mentioned. Information about the elevator or room orientation is nevertheless also sporadic. We have found that the advertisements of apartments with attractive views have this benefit mentioned in the description. For a part of the advertised apartments, photographs of the surroundings are included, especially when they are nearby the historical part of Prague. Technical parameters always include floor area. The method of heating is mentioned in the textual part of most advertisements, or the method of heating is apparent at the photo documentation. Energy efficiency is not often stated. Contributions to the maintenance fund are mentioned sporadically. The price info usually mentions also whether the price includes a commission or not, or whether it is a direct sale from the developer. Advertisements are written in Czech, sometimes also in English.

Figure 1. Example of a floor plan (sreality.cz, 2023a)

Figure 2. Example of future state visualization for reconstruction (sreality.cz, 2023a)

3.3. Furhter Marketing Communication Diifferences – Small Apartments in Standard Locations in Medium-sized Cities

These apartments are mostly intended as starter homes or for childless couples. The apartments' adverts are linked with the impression of the possibility of permanent living. The information that the apartment is suitable as an investment is only sporadically provided. These apartments are commonly in panel or brick buildings. Their home staging is rarely used. In case of developmental projects the visualization of the future state is standardly used, while for apartments which are used for living, only the current state documentation is provided. Only in a few cases the apartment's floor plan was included. The description of individual apartments is balanced regarding the location and the property's condition. Advertisements often start with common phrases like "Apartment for sale offer," "We offer an apartment," or "Looking for a quiet apartment in this location." The information about the age of the apartments normally used for living is not very common in the advertisements. It is usually stated that the apartment is in good condition. In case of the apartment, which is in its original condition, this is frequently mentioned that for instance in the following manner: "the apartment is in its original maintained condition, suitable for reconstruction." It is also expressly stated that it is a new building if it is the case. Photographs are mostly taken with standard lenses; but small rooms are specifically photographed with wide-angle lenses. Drones are only rarely used in this category (see Figure 3). The description of apartments in this category is usually simple, customer-oriented in order to encourage them to come and see the apartment in person. In most cases, the street where the apartment is located is mentioned. It is nevertheless not always apparent what the conscription number of the building is even from the attached map. The floor on which the apartment is located is standardly mentioned. The information about the elevator or room orientation is nevertheless less common. The photo documentation often includes the surroundings (e.g.,

a possibility of parking in front of the building or a playground). The view from the window is only sporadically included. The floor area is always mentioned among the technical parameters. The method of heating is mentioned more often in the textual part of most advertisements, or the method of heating is apparent from the photo documentation. The energy efficiency is not often stated and also obligatory contributions to the maintenance fund are mentioned sporadically. The price info usually mentions whether the price includes a commission or not, or whether it is a direct sale from the developer. The advertisements are always written in Czech.

Figure 3. Example of photograph with the apartment highlighted, taken from a drone (sreality.cz, 2023c)

3.4. Yet Another Marketing Communication Differences – Large Appartments in Lucrative Locations in Prague

These are apartments intended for own living or for subsequent rental. In the case of rentals, short-term leases such as Airbnb or booking.com prevail. The information about the rental amount is seldom provided. Mostly, these apartments are located in historical brick buildings. The home staging is prevalent and visualizations are not uncommon. The visualizations are well processed and at first glance, it is not apparent that they are graphics created using specialized software. In some cases, floor plans are included. The description of individual apartments is primarily designed to highlight the attractiveness of the location. Partially, the advertisements mention the potentialities of the apartment in question. The advertisements also often start with common phrases like "Apartment sale," "We offer an apartment for sale in the center of Prague," and the like. Occasionally, there is a mention of barrier-free access. The advertisements of the apartments in historical buildings sometimes mention the history of the building itself. Luxurious elements of the apartments are noted if it is the case. As concerning the apartments in good condition, recent renovations are mentioned, while in case of older apartments, it is usually stated that the property is in good condition. Their photographs are taken with standard lenses, while small rooms (bathrooms,

corridors) are captured with wide-angle lenses. The vast majority of photographs are artificially illuminated in order to show that the apartment is lightened by sun (see Figure 4). Drones are not used in this category. The descriptions of apartments in this category are usually extensive, they usually balance description of the location and the condition of the apartments. The descriptions primarily content the positives of the specific property. In most cases, the street where the apartment is located is mentioned. Sometimes, the conscription number is apparent at attached maps (in the text, the conscription number is usually not mentioned). It is a rule that the floor on which the apartment is located is mentioned. The information about the elevator is usually provided. The information about the room orientation is mostly exceptional. The descriptions usually do not miss highlighting the significant places in the surroundings especially historical monuments. Technical parameters always include the floor area but usually do not distinguish between the floor area of the apartment in question and the balconies, terraces, loggias, or cellars. The method of heating is mentioned in the textual part of most of the advertisements or it is apparent from the photo documentation. The energy efficiency is not often stated. Obligatory contributions to the maintenance fund are mentioned sporadically. The price info usually mentions whether it includes commission or not or whether it is a direct sale from the developer. The advertisements are written in Czech and occasionally in English.

Figure 4. Example of a photograph of the view from the window on historical monuments (sreality.cz, 2023b)

3.5. Last Marketing Communication Differences - Large Appartments in Standard Locations in Medium-sized Cities

These apartments are intended for the own living of a typical family in the Czech Republic. Predominantly, these are apartments in panel buildings. The information about the possibility of renting is rare. If the apartment is rented, the amount of annual rent is then mentioned. The home staging is not widely applied. As concerning new apartments visualizations and floor plans are included. In case of older apartments floor plans are usually

absent. The descriptions of individual advertisements primarily focus on the apartment itself, marginally on its location. The advertisements often start with common sales phrases like "Apartment for sale," "We offer an apartment for sale", etc. Occasionally, barrier-free access is mentioned. As far as new constructions are concerned, this condition is mentioned. For older buildings, the condition is typically mentioned as good. The descriptions of an older property are minimalistic. The photographs are taken with standard lenses, while small rooms (bathrooms, corridors) are captured with wide-angle lenses (see Figure 5). Most of the photographs are artificially illuminated while drones are used exceptionally in this category. The description of apartments in this category is basic, the description of the apartment is usually prioritized over the description of the building and its location. The descriptions primarily contain the positives of the specific property. In most cases, the street where the apartment is located is mentioned. It is not always apparent from the attached map what the conscription number is not always apparent at attached maps (in the text, the conscription number is usually not mentioned). It is a rule that the floor on which the apartment is located is included. The information about the elevator is usually provided while the information about the room orientation is mostly exceptional. Technical parameters always include the floor area but it is usually not possible to distinguish what is the floor area of the apartment and what are balconies, terraces, loggias, or cellars. The method of heating is mentioned in the text part of most advertisements, or the method of heating is apparent from the photo documentation. The energy efficiency is not often stated and also the sum of contributions to the maintenance fund are mentioned sporadically. The price info usually mentions whether it includes commission or not, or whether it is a direct sale from the developer. The advertisements are written in Czech.

Figure 5. Example of standard photograph of apartment (sreality.cz, 2023d)

4. Discussion

The results of the study indicate that the real estate sector is strongly linked to specific locations and local markets. The location is often a key factor in buyers' decision-making.

Therefore, the marketing in the real estate sector is often focused on promotional activities in specific geographical areas. The sale of a property in question is a long-term process that can last several months. Even if a client decides to proceed faster, the transaction can be not concluded within legal deadlines related to the transfer of property ownership. The visual elements of the marketing in the real estate sector include photographs, videos, and property descriptions. These criteria are important because buyers often select properties based on their visual presentation. Thus, the study confirms the significance of the visual elements in the marketing communication, as previously indicated by the research of Belniak and Radziszewska-Zielina (2019).

Furthermore, we have found that the purchase of the real estate properties is often strongly connected to emotions. The marketing in the real estate sector frequently emphasizes feelings of home, security, and comfort. The emotional aspect plays a more significant role than in some other sectors. Similar conclusions are pointed out by the research studies of Xiao (2008) and Gotwaldová (2015). There are seasonal fluctuations in the real estate sector mentioned with higher demand for properties in summer, while the demand decreases towards the end of the year. Just like in other sectors, regulations related to advertising, contracts, and ethics must be adhered to. Some marketing principles are universal but the real estate sector has specific characteristics and needs which require the adaptation of common strategies for effectively targeting relevant audiences. The marketing at social networks often serves merely as a link to the websites of real estate agencies or real estate portals. The marketing communication elements must be implemented in compliance with the law, for example, the use of drones for photographing is legal only under certain conditions.

5. Conclusions

This study analysed the online platforms used in marketing communication in the context of the real estate sector in the Czech Republic. Moreover, it identified the differences in sales communication across the variety of apartment size groups and locations. Each broker has his marketing strategy that he applies. Based on our survey we have found that advertisements for the sale of similar apartments in similar locations exhibit similar characteristics. Similar marketing tools are applied in various different groups of apartment advertisements that share the same characteristics. Most brokers use a standard concept of marketing strategy. Some brokers create a specific marketing concept to differentiate their advertisements from those of other brokers. Creating a story about the offered property has recently started to appear in the advertisements. Our study also found that in the vast majority of offers, only the positives of the specific real estate property are highlighted. The information about negative factors is exceptional. With the increase in the offered price, the quality of marketing communication increases, which is influenced by the commission from the sale.

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Digital Economy Drives the Transformation and Upgrading of Western Service Industry

Kai LI, Rong KANG and Chao YANG*

School of Economics and Management, Northwest University, Xi'an, China; 499413655@qq.com;
kangrong@nwu.edu.cn; yc19980417@163.com

* Corresponding author: yc19980417@163.com

Abstract: This article discusses the important role of Internet popularization and the development of digital inclusive finance in promoting the transformation and upgrading of the western service industry, and conducts a theoretical review from the perspective of digital economic development. At the same time, by measuring the degree of upgrading of the service industry structure in each province in the west, this article finds that regions with a higher level of comprehensive economic development have a higher degree of transformation and upgrading of the service industry. The difference in the degree of upgrading of the service industry in the western region mainly comes from provinces. This article conducts a panel data model analysis on the data of 12 western provinces from 2016 to 2020 to explore the impact of the development level of the digital economy on the transformation and upgrading of the service industry. The research results show that the improvement of the development level of the digital economy can optimize the industrial structure of the service industry and promote the transformation and upgrading of the service industry in the western region.

1. Introduction

The report of the 20th National Congress of the Communist Party of China pointed out that high-quality development is the primary task of comprehensively building a modern socialist country. To accelerate the construction of a new development pattern and strive to promote high-quality development, it is necessary to promote the upgrading of the industrial structure and accelerate the development of the modern service industry. The efficient development of the service industry is one of the keys to achieving high-quality economic development, and promoting the transformation and upgrading of the service industry is key measures to achieve this goal. With the continuous development and update of digital technology, the digital economy, as a new economic form, plays an important role in the development of the modern service industry and the allocation of service resources. Digital technology also plays an important role in promoting the transformation and upgrading of the service industry. Under the requirements of implementing the strategy of expanding domestic demand and deepening the supply-side structural reform, the main driving force

for the transformation and upgrading of the service industry now comes from "service digitalization" and "digital servitization".

Under the development pattern of the service industry driven by digital technology, the technological revolution with a new generation of digital universal technology as the core has the advantage of transcending geographical characteristics and reshaping the geographical pattern, thus providing opportunities for the development of the service industry in the underdeveloped western region. For the western region, relying on digital economic development with digital technology as the core is an important means to achieve an advanced development of the service industry structure. The digital economy drives the transformation and upgrading of the western service industry, which plays a vital role in improving the development level and efficiency of the western service industry, promoting high-quality economic development in the western region, and helping the western region catch up and surpass.

Domestic and foreign scholars generally believe that the digital economy, as a new endogenous factor driving the transformation and upgrading of the service industry, has had a positive effect. Kaplinsky and Morris (2012) found that under the guidance of national policies, the accelerated transfer, diffusion and absorption of information technology can promote the development of the modern service industry. According to research by Wang (2013), digital technology innovation is becoming increasingly active, and at the same time, the competitive landscape of knowledge and technology-intensive service industries is also undergoing changes. In this case, the key to the transformation and upgrading of the service industry is to properly handle the deep integration of traditional service industries and information technology, and to cultivate emerging service industries. According to Zhang (2015), in the current economic development, the relative lag of the modern service industry is an existing problem. This situation can be alleviated by promoting the deep integration of information technology and the service industry and relying on information technology to transform the traditional service industry. Pisano (2015) pointed out that with the major breakthroughs in mobile Internet technology, the economic model based on the Internet platform can achieve instantaneous and accurate matching of traditional service supply and demand, improve the level of personalization and customization of services, and promote the development efficiency of the service industry. Dong (2015) took the integrated development of the Internet and traditional service industries as an entry point and believed that information technology is driving a new round of changes in the service industry and becoming an important point of new economic growth. Zeng and Gao (2016) believe that Internet technological innovation is changing the global industrial structure, giving rise to new service business models, improving the quality of service consumption, improving the efficiency of service supply, and promoting the transformation and upgrading of the service industry.

To sum up, although domestic and foreign scholars have begun to pay attention to the positive role of information technology in promoting the transformation and upgrading of the service industry and believe that it is an important means to break through the "bottleneck" of the development of the service industry, it is still difficult to promote the transformation and upgrading of the service industry in the development of the digital economy. There is still a big

lack of theoretical mechanism and empirical research. In addition, because the development level of the service industry in the western region is lower than that in the eastern region, there are relatively few specific studies on the transformation and upgrading of the service industry in the western region. This article explores its impact on the transformation and upgrading of the western service industry from the two perspectives of Internet popularization "dividends" and digital inclusive finance brought about by the development of the digital economy, based on prefecture-level city data from 2016 to 2020. Due to the complexity and variability of the internal structure of the service industry, there are inconsistent views on the classification of the service industry, and then the definitions and connotations of the internal industrial structure upgrade of the service industry are also diverse. When studying the relationship between the industrial structure and productivity of the service industry, Baumol (1967) pointed out that there are traditional sectors and high-end sectors within the service sector. He believes that only when production factors flow to advanced high-end sectors can the transformation and upgrading of the service industry be realized, thereby promoting the improvement of service industry productivity. The connotation of defining the upgrading of the service industry structure is the expansion of the proportion of the high-end service sector, and the degree of advanced service structure is defined as including information transmission, computer services and software industries, finance, leasing and business services, scientific research, technology. The proportion of employees in the service and geological exploration industries has increased.

2. Theoretical Analysis of the Promotion Mechanism and Effects of Digital Economy on the Transformation and Upgrading of the Service Industry in the Western Region

The development of the digital economy has changed people's production and lifestyle today. Among them, the popularization of the Internet and the development of digital inclusive finance brought about by the development of the digital economy have played an important role in the transformation and upgrading of the service industry.

2.1. Internet Popularization and Transformation and Upgrading of the Service Industry

With the development of the digital economy, digital technology has accelerated its comprehensive penetration and integration into the service industry. As a low-cost infrastructure for processing information, the new element of the Internet not only implants new genes into the traditional service industry, making it flourish; it has also spawned many new service industries. With the rapid development of the digital economy, the Internet has become an indispensable and important production factor in the service industry, which has had a comprehensive impact and promoted the upgrading of the industrial structure of the service industry. In this context, the Internet, as a service tool, combines with the demand side and supply side of the traditional service industry to promote the transformation and upgrading of the traditional service industry into the modern service industry.

First, the popularization of the Internet promotes the transformation and upgrading of the service industry from the perspective of supply and demand mechanisms. With the popularization of the Internet, the sharing economy, as a newly developed model, has

facilitated the supply and demand of the service industry. The role of the Internet economy in the service industry is not only reflected in technology, but also in that it changes the way of collaboration and communication within the service industry and enhances trust and cooperation between organizations. This change provides a new interpretation framework for the supply mechanism of the service industry, makes the division of labor and collaboration in the service industry more efficient and flexible, and creates better conditions for the transformation and upgrading of the service industry. Wong et al. (2015) believe that the popularization of the Internet is conducive to broadening service consumption channels and increasing opportunities for service supply mechanisms; with the popularization of Internet technology on the demand side, the sharing economy has become a new business model, through timely collection, sorting, transmission and analysis of services Data in the marketing and consumption process accurately reflect the rules of service consumption activities and service innovation needs. These data elements provide an important information basis for promoting the transformation and upgrading of the service industry. Therefore, the popularity of the Internet has become the main engine driving the rapid growth of service consumption in the Internet era. Therefore, we can conclude that the increase in Internet penetration included in the development of the digital economy enables the use of mobile Internet technology platforms in terms of service supply and demand to achieve timely matching and coordination of service supply and demand, improve service supply efficiency, and promote service transformation and upgrading.

Second, the popularization of the Internet has reduced the transaction costs of service supply and demand, helping the service industry to transform and upgrade. A typical feature of service consumption is that the service provider and the consumer are very close in time and space, which means that before consumption, the consumer is usually at an information disadvantage. Information asymmetry may cause consumers to make adverse choices, which will affect the healthy operation of the market and even cause bad money to drive out good money. The popularization of the Internet can largely overcome the information asymmetry problem that exists in the service consumption process. Adda and Saad (2014) believes that the Internet model has changed the environment and norms of traditional business competition, providing an opportunity to cultivate new business rules for service consumption. In addition, Wang (2015) pointed out that the development of China's modern service industry requires the help of "Internet +" and sharing economic platforms, and the development and popularization of the Internet provide strong technical support for the innovation of new service business models. The popularization of the Internet under the development of digital economy has created a good trading environment for the transformation and upgrading of the service industry.

2.2. The Impact of Digital Inclusive Finance on the Transformation and Upgrading of the Service Industry

Digital inclusive finance is a new type of financial service based on the combination of Internet digital technology and finance. Through its innovative functions and wide range of service objects, it makes up for the shortcomings of traditional financial services and meets

the needs of broad social groups for financial services. It also Promoted the transformation and upgrading of the service industry.

First, digital inclusive finance reduces the financing costs of service industry companies and promotes the upgrading of the service industry structure. High-end manufacturing is generally a knowledge-intensive industry, so it requires greater financial support than labor-intensive industries, and therefore has higher financing needs. The impact of digital inclusive finance on the structural upgrading of the service industry can be realized through two channels: direct and indirect. On the direct path, digital inclusive finance is more convenient than traditional financing channels and can reduce corporate financing costs, thereby promoting the transformation and upgrading of the service industry; on the indirect path, digital inclusive finance can alleviate financing difficulties in the manufacturing industry and promote local The upgrading of the manufacturing industry will create demand for high-end service industries and further promote the upgrading of the service industry. In addition, digital inclusive finance has different impacts on different levels of service industries. For non-high-end service industries, they can cope with unfavorable factors such as increased costs by raising product prices, while high-end service industries are more sensitive to increased costs. It may cause the industry to shrink and hinder the transformation and upgrading process of the service industry. Therefore, digital inclusive finance promotes the transformation and upgrading of the service industry by easing the financing difficulties of modern service companies.

Second, digital inclusive finance can promote the transformation and upgrading of the service industry by improving the service factor market. The development of digital inclusive finance can reduce the "pickiness" of financial services for various industries in the service industry through inclusive financial services, ensure "equal treatment", especially provide convenient financial services for small and medium-sized service enterprises, and reduce the capital factor Problems such as structural imbalance in the service industry caused by distorted allocation. Digital inclusive finance relies on the support of digital technology. Its rise has given rise to the rapid development of Internet information technology and financial technology, promoted the improvement of relevant scientific and technological talents, improved the quality of production factors, optimized the allocation of resources, and also promoted It has promoted the digital transformation of service-oriented enterprises, thereby promoting the upgrading and development of the service industry.

To sum up, this article believes that the development process of the digital economy, the popularization of the Internet and the development of digital inclusive finance will promote the upgrading of the service industry structure in terms of service industry supply and demand, transaction costs, financing and resource allocation.

3. Pre-judgment and Difference Analysis of the Transformation and Upgrading of the Service Industry in the Three Western Regions

3.1. Descriptive Analysis of the Upgrading of Service Industry Structure in Western Provinces

It is generally believed that the increase in the proportion of producer services and high-end services in the service industry will help alleviate Baumol's "cost disease" and realize the

optimization and upgrading of the internal structure of the service industry (Eichengreen & Gupta, 2013). Therefore, drawing on the estimation ideas of Yu and Pan (2019) and Wang et al. (2020), this paper uses the proportions of producer services and high-end services in the total number of employees in the service industry to describe the structure of the service industry. Among them, the producer services mainly include transportation, warehousing and postal services, information transmission, computer services and software, finance, leasing and commercial services, scientific research, technical services and geological exploration. Considering the existence of some traditional service industries in the transportation, warehousing and postal industries, this paper defines the high-end service industry as the other four industries in the producer service industry in addition to the transportation, warehousing and postal services.

By measuring the advanced level of the service industry structure in the western region from 2016 to 2020, the results are shown in Table 1.

Table 1. Advanced index of service industry structure in western provinces

	2016	2017	2018	2019	2020
Inner Mongolia Autonomous Region	0.1626	0.1652	0.1757	0.2002	0.2213
Guangxi Zhuang Autonomous Region	0.1597	0.1582	0.1644	0.1635	0.1632
Chongqing	0.1866	0.1772	0.1694	0.1806	0.2124
Sichuan Province	0.2111	0.2072	0.2131	0.2089	0.2079
Guizhou Province	0.1371	0.1393	0.1430	0.1573	0.1725
Yunnan Province	0.1508	0.1557	0.1552	0.1668	0.1790
Tibet Autonomous Region	0.1328	0.1104	0.0994	0.1507	0.1842
Shaanxi Province	0.2056	0.2030	0.2081	0.2221	0.2341
Gansu province	0.1444	0.1630	0.1349	0.1536	0.1721
Qinghai Province	0.1989	0.1879	0.1791	0.1970	0.2105
Ningxia Hui Autonomous Region	0.1938	0.1783	0.1685	0.1947	0.2176
Xinjiang Uygur Autonomous Region	0.1675	0.1754	0.1685	0.1678	0.1736
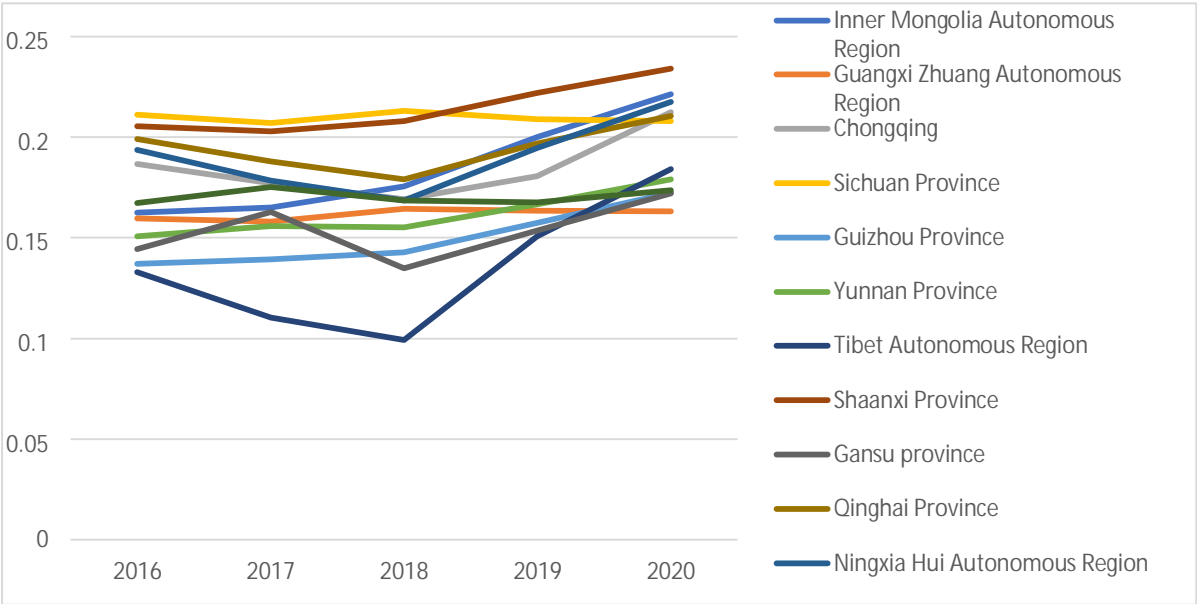
Figure 1. Changes in the upgrading of the service industry structure in western provinces in years 2016-2020 (vertical axis = the industrial structure advanced index)

In order to more clearly observe the changes in the degree of advanced service industry structure in various western provinces, Figure 1.

As shown in Figure 1, the overall level of service industry structure in various western provinces tends to be advanced, and the index of advanced service industry structure has increased. The Tibet Autonomous Region showed a trend of first declining and then rising during the sample investigation period, and overall, the service industry structure advanced index increased by 38.7% in 2020 compared with 2016, making it the region with the largest increase in the west; Shaanxi Province and Sichuan Province the average service industry structure upgrading index is at the forefront of the western provinces. The reason is that these provinces have better economic development in the western region, so talents, capital and other factors flow to these provinces, especially Xi'an and Chengdu, which are the economic pillars of the western region. In "bridgehead" cities, the modern service industry has advantages over other regions in terms of factor supply and service consumption, which has accelerated the transformation and upgrading of the service industry in these regions. At the same time, Shaanxi Province and Sichuan Province have a relatively high level of digital economic development. Based on the above analysis, it can also be seen that they have a promoting effect on the upgrading of the service industry structure. The average value of the advanced industrial structure index in Guizhou Province is 0.14984, ranking second from the bottom, only higher than the Tibet Autonomous Region. According to the "China Digital Economy Development White Paper (2020)" released by the China Academy of Information and Communications Technology, Guizhou Province's digital economy grew at a growth rate of 22.1% in 2019, ranking first in the country for five consecutive years. Its digital economy has developed rapidly, but its level of advanced service industry structure is low. The reason is that the traditional service industry in Guizhou Province has developed relatively slowly, and the ability to combine digital technology with the service industry still has great potential. That is, the level of "service digitalization" needs to be improved, which has led to Guizhou Province's The service industry structure is not sufficiently advanced.

3.2. Decomposition of Dagum Gini Coefficient of Service Industry Structure Upgrading Index in Western Provinces

In the previous section, we compared the gaps and changes in the upgrading of service industry structures in various western provinces. This section explores where the differences come from. This article reveals the regional differences and sources of the transformation and upgrading of the service industry in western provinces based on the Gini coefficient proposed by Dagum (1997). The coefficient is divided into intra-regional contribution G_w, inter-regional contribution G_{nb} and hyper-variable density contribution G_t, and the relationship between the three is $G = G_w + G_{nb} + G_t$. The specific method is as follows:

$$G = \frac{\sum_{j=1}^{k}\sum_{h=1}^{k}\sum_{i=1}^{n_j}\sum_{r=1}^{n_h}|y_{ji} - y_{hr}|}{2n^2\mu} \tag{1}$$

Among them, G represents the overall Gini coefficient; k is the number of provinces; n is the total number of cities in the west; in this article n is 95; and $n_j(n_h)$ is the number of cities

in the j(h) province; $y_{ji}(y_{hr})$ is the j(h) province Internal urban service industry structure upgrading index; μit is the average value of all urban service industry structure upgrading indexes. Before decomposing the Dagum Gini coefficient, it is necessary to sort the average values of the service industry structure premium index in each province from small to large.

$$\bar{y}_1 \leq \bar{y}_2 \leq \cdots \leq \bar{y}_j \leq \cdots \leq \bar{y}_k \tag{2}$$

$$G_{jj} = \frac{1}{2\mu n_j^2} \sum_{i=1}^{n_j} \sum_{r=1}^{n_j} |y_{ji} - y_{ir}| \tag{3}$$

$$G_{jh} = \frac{\sum_{i=1}^{n_h} \sum_{r=1}^{n_h} |y_{ji} - y_{hr}|}{n_j n_h (\mu_j - \mu_h)} \tag{4}$$

The above formulas respectively represent the Gini coefficient of the j province G_{jj} and the inter-regional Gini coefficient of provinces j and h. $\bar{y}_j$ and $\bar{y}_h$ represent the service industry structure upgrading index of province j and province h respectively; n_j and represent the number of cities included in province n_h j and province h respectively. Furthermore, the overall Gini coefficient is decomposed into intra-regional Gini coefficient, inter-regional Gini coefficient and hypervariable density, as shown in the formula:

$$G = G_w + G_{nb} + G_t$$

The following formulas describe the calculation methods of intra-regional Gini coefficient, inter-regional Gini coefficient and hypervariable density respectively:

$$G_w = \sum_{j=1}^{k} G_{jj} P_j S_j \tag{5}$$

$$G_{nb} = \sum_{j=2}^{k} \sum_{h=1}^{j-1} G_{jh}(p_j s_h + p_h s_j) D_{jh} \tag{6}$$

$$G_t = \sum_{j=2}^{k} \sum_{h=1}^{j-1} G_{jh}(p_j s_h + p_h s_j)(1 - D_{jh}) \tag{7}$$

in, $p_i = \frac{n_j}{n}, s_j = (n_j \bar{y}_i)/(n\bar{y})$. Moreover, $\sum p_j = \sum s_j = \sum_{j=1}^{k} \sum_{h=1}^{k} p_j s_h = 1$。 D_h it represents the relative impact of the degree of service industry upgrading between the j and h regions , and the calculation formula is :

$$D_{jh} = \frac{(d_{jh} - p_{jh})}{(d_{ih} - p_{jh})} \tag{8}$$

In the following formula, d_{jh} and p_{jh} respectively represent the mathematical expectation of the sum of all sample values in provinces $y_{ji} > y_{hr}$ j and h and the average of the sum of all sample values in provinces j $y_{ji} < y_{hr}$ and h. The calculation formulas for both are as follows. Among them, F_j、 F_h represent the cumulative distribution function of j and h regions respectively.

$$d_{jh} = \int_0^\infty dF_j(y) \int_0^y (y - x) dF_h(x) \tag{9}$$

$$p_{jh} = \int_0^\infty dF_h(y) \int_0^y (y - x) dF_j(x) \tag{10}$$

3.3. Analysis of Differences in the Upgrading of the Service Industry Structure in Western Provinces

Overall difference analysis

Based on the Gini coefficient mentioned above, the degree of urban service industry upgrading in 12 western provinces from 2016 to 2020 was calculated. Since Chongqing is one of the four major municipalities in China, the Gini coefficient cannot be calculated, so it was eliminated. According to the data in Table 2, the average Gini coefficient of the overall advanced service industry structure in western provinces during the investigation period was 0.2353, showing an overall fluctuating trend.

Table 2. Advanced index of service industry structure in western provinces

	2016	2017	2018	2019	2020
overall	0.2262	0.2464	0.2424	0.2151	0.2462
Yunnan Province	0.1891	0.2156	0.2317	0.1993	0.2031
Xinjiang Uygur Autonomous Region	0.2970	0.3116	0.3003	0.2563	0.2323
Shaanxi Province	0.1981	0.1981	0.1891	0.1895	0.2368
Sichuan Province	0.1661	0.1642	0.1512	0.1354	0.2071
Tibet Autonomous Region	0.5056	0.6276	0.5748	0.3991	0.4534
Inner Mongolia Autonomous Region	0.1178	0.1171	0.1412	0.1646	0.1885
Qinghai Province	0.1840	0.1625	0.1287	0.1891	0.2317
Ningxia Hui Autonomous Region	0.1848	0.1568	0.1424	0.1675	0.2342
Gansu province	0.2507	0.2835	0.2450	0.2415	0.2665
Guangxi Zhuang Autonomous Region	0.1636	0.1737	0.1931	0.1590	0.1551
Guizhou Province	0.1388	0.1392	0.1332	0.0824	0.0702

Analysis of intra-regional differences

As can be seen from Table 2, the level of intra-regional differences in the 12 provinces in western China shows a differentiated evolution trend. During the inspection period, the highest annual mean value of difference within the region was in the Tibet Autonomous Region, reaching 0.5121; followed by the Xinjiang Uygur Autonomous Region (0.2795), Gansu Province (0.2574), Yunnan Province (0.2078), Shaanxi Province (0.2023), and Qinghai Province (0.1792), Ningxia Hui Autonomous Region (0.1771), Guangxi Zhuang Autonomous Region (0.1689), Sichuan Province (0.1648), Inner Mongolia Autonomous Region (0.1458), Guizhou Province has the lowest annual mean value of intra-regional difference, only 0.1128. The general Gini coefficient within the western provinces shows a trend of " one super and many strong", that is, the difference value within the Tibet Autonomous Region from 2015 to 2021 far exceeds that of other provinces, and the difference values of the remaining 11 provinces during the investigation period are all the same. The difference is not big and shows a state of fluctuation. Among them, Xinjiang Uygur Autonomous Region, Guangxi Zhuang Autonomous Region and Guizhou Province generally show a downward trend, indicating that

the degree of advanced service industry structure among the cities in the province is relatively average and the differences gradually become smaller; the differences within the remaining provinces All have expanded more or less. Taking a closer look at the data, we found that the widening gap in the degree of advanced service industry structure between central cities in some provinces and other cities in the province has caused an increase in the Gini coefficient value within the province. The reason is, Cities with strong "siphon" effects such as Xi'an and Chengdu attract talents and funds, resulting in uneven urban development, which in turn leads to a large gap between the levels of modern service industries.
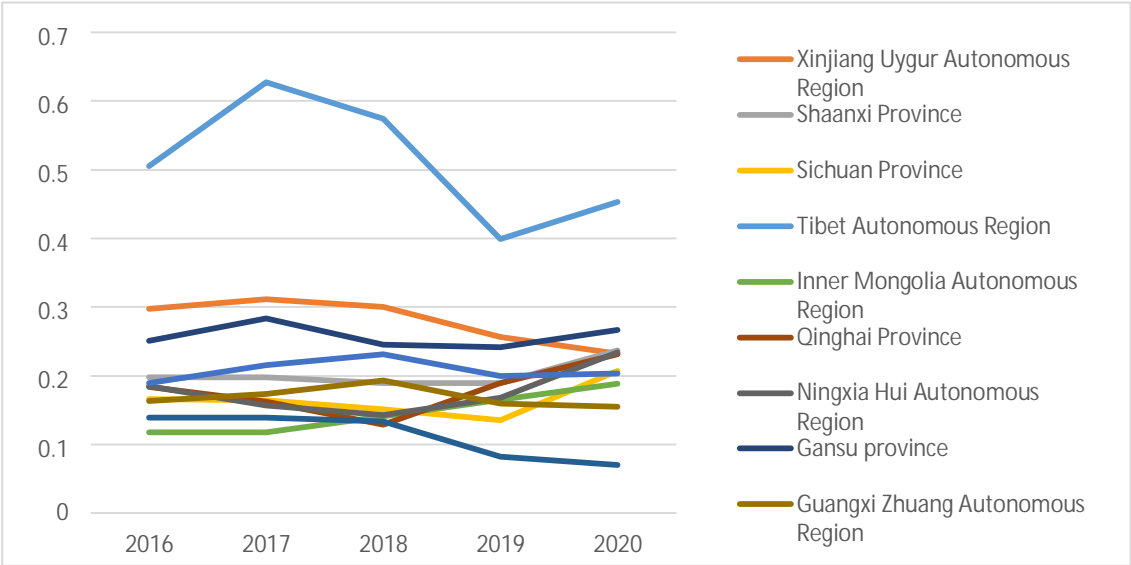
Figure 2. Changes in intra-provincial differences in the advanced service industry structure in western provinces. The horizontal axis in the figure is the year, and the vertical axis is the Gini coefficient.

Provincial difference contribution rate

Table 3 shows the overall sources of differences in the degree of advanced service industry structure in 12 provinces in China. It can be seen that the differential contribution rate of hypervariable density is the highest, with an average annual contribution rate of 48.1% during the investigation period; followed by the inter-regional contribution rate, with an annual average value of 42.418%; the contribution rate within a region is the smallest, with an annual average value of 9.242%. Obviously, the most important sources of overall differences in the upgrading of the service industry structure in western provinces are hypervariable density and inter-regional differences. It shows that narrowing the gap in the transformation and upgrading development of the service industry among the western provinces should focus on resolving inter-regional differences, and the modern service industry in the western provinces should develop collaboratively.

Table 3. Differential contributions to the upgrading of service industry structure in western provinces

years	2016	2017	2018	2019	2020
Within the area	9.42%	8.97%	8.78%	9.17%	9.87%
interregional	40.81%	40.25%	48.32%	43.18%	39.53%
hypervariable density	49.77%	50.78%	42.9%	47.65%	49.4%

4. Empirical Research on Digital Economy Driving the Transformation and Upgrading of Service Industry in Western China

4.1. Research Design

Data source

The data used in this article come from the China Urban Statistical Yearbook and the Western Region Provincial Statistical Yearbook. The time span is from 2016 to 2020. The research scope includes 12 provinces in the Western Region, covering 95 prefecture-level cities. To ensure the reliability of the data, the original data were processed and standardized, and interpolation was used to fill in some missing values. Additionally, winsorization was performed to avoid outliers or extreme values from adversely affecting the results.

Variable description

Interpreted variable. The degree of upgrading of the service industry structure *upgrade*. This article considers using the development level of the high-end service industry to measure the structural upgrading of the service industry. When selecting indicators, this article refers to the research methods of Yu and Pan (2019) and uses the proportion of high-end service industry employees as the research indicator to reflect the degree of sophistication of the service industry structure.

Explanatory variables. Digital economy *Dige*. There is currently a lack of comprehensive measurement research on the development level of the digital economy. The focus of this study is to explore the impact of Internet popularization and digital inclusive finance on the transformation and upgrading of the service industry. To this end, we draw lessons from the measurement core of Zhao (Zhao et al., 2020) and others, and combine the index construction ideas of digital financial inclusion to measure Internet development at the city level. Specifically, four indicators are used to measure the level of Internet development: Internet penetration rate, related employees, related output, and mobile phone penetration rate. Data for these indicators can be obtained from the China Urban Statistical Yearbook. In addition, in order to measure the development level of digital finance, this article uses the China Digital Financial Inclusion Index. By standardizing and reducing dimensionality of the above indicators, the digital economy development index *Dige* was obtained.

Control variables.

- The level of economic development *agdp*. The level of economic development in a region often affects the industrial structure of the local service industry. The per capita consumption levels in different regions often lead to different consumption structures. In turn, the consumption structure of the region affects the changes in the industrial structure of the service industry. This article chooses the logarithm of per capita GDP (yuan) of prefecture-level cities as an indicator of the level of people's economic development.

- Urbanization level *urban*. Different regions have different urbanization levels that will have an impact on the transformation and upgrading of the service industry. The difference in consumption between urban and non-urban populations affects the degree of transformation and upgrading of the local service industry. Therefore, the proportion

of the urban population to the total population of the city is selected. (%) as an indicator of this variable.

- City *size scale.* The size of a city has an impact on the transformation and upgrading of the service industry. A larger city has a larger market in terms of service supply and demand. At the same time, economies of scale can also help improve the production efficiency of the service industry and promote the transformation and upgrading of the service industry. Therefore, this article the logarithm of the total population of prefecture-level cities was chosen as the indicator of this variable.

- The level of human capital accumulation *university.* The transformation and upgrading of the service industry means that the regional service industry gradually transforms from a labor-intensive to a knowledge-intensive industry. Therefore, it will be affected by the level of human capital accumulation. Therefore, the logarithm of the number of universities in prefecture-level cities is chosen as this indicator.

Model construction

In order to study the impact mechanism of digital economic development on the transformation and upgrading of the service industry in the western region, this study constructed the following econometric model:

$$upgrade_{it} = \alpha + \beta_0 Dige_{it} + \beta_1 agdp_{it} + \beta_2 urban_{it} + \beta_3 scale_{it} + \beta_4 university_{it} + \varepsilon_{it}$$

Among them, *i* represents the prefecture-level city, and *t* represents the year. The following table lists the variables used in this study and their data characteristics.

Table 4. Descriptive statistics of variable indicators

variable	Number of samples	mean	standard deviation	minimum value	maximum
upgrade	475	0.150	0.058	0.046	0.411
Dige	475	0.203	0.531	-0.920	3.439
agdp	475	10.674	0.525	9.384	12.281
urban	475	0.974	0.220	0.079	1.107
scale	475	5.642	0.801	3.045	8.136
university	475	1.142	1.102	0	4.174

4.2. Empirical Analysis

Regression Analysis

In order to effectively process and analyze panel data, it is necessary to take into account the endogeneity and heterogeneity of the model and select an appropriate estimation method. Panel data models usually have three forms, namely mixed estimation models, fixed effects models and random effects models, among which fixed effects and random effects models are both variable intercept models. This study first uses the mixed regression model for verification, and uses the F test to determine whether the mixed regression estimation method is used. However, the regression results show that the regression coefficients of the explanatory variables on the explained variables are not significant, and the F test results reject the null hypothesis at the 1% significance level. Since the mixed estimation model requires that there are no significant differences between individuals in time and cross-section, it can be speculated that using mixed regression that ignores sample characteristics may lead to biased

Table 5. Descriptive statistics of variable indicators

variable	Model
Dige	0.204*
	(0.076)
agdp	0.029***
	(0.006)
urban	0.068***
	(0.013)
scale	-0.007
	(-1.59)
university	0.017***
	(0.00)
Constant term	-0.189*
	(0.07)
Hausman test	10.08***
	[0.0000]
Observations	475
R-squared	0.552

Note: ***P < 0.01, **P < 0.05, *P < 0.1. The t value is in () and the P value is in [].

empirical analysis results. Next, we use the Hausman test to determine whether the fixed effects model or the random effects model is the optimal estimation method.

According to the regression results in Table 5, the results obtained using the fixed effects model are optimal. In addition, the Hausman test was used to test whether there is a correlation between the random disturbance term and the explanatory variable. The result showed that the P value was less than 0.01, rejecting the null hypothesis that the random disturbance term has nothing to do with the explanatory variable. This further supports that the fixed effects model is optimal. conclusion.

According to the regression results in Table 5, after controlling for per capita GDP, urbanization level, city size, human capital accumulation level and other factors, the regression coefficient of the explanatory variable is 0.204. This regression coefficient has been tested at the 10% significance level, proving that the level of digital economy development has a positive effect on the optimization and upgrading of the service industry industrial structure. This means that increasing investment in digital economy construction and improving the development level of the digital economy will help optimize the industrial structure of the western service industry. According to the above analysis, the reason is that the popularization of the Internet and the development of digital inclusive finance in the development of the digital economy have provided support for the smooth promotion of the transformation and upgrading of the service industry. In terms of supply and demand in the service industry, the development of the digital economy has broadened information communication channels and reduced transaction costs, and has significant positive external effects on the transformation and upgrading of the service industry; at the same time, the development of the digital economy has directly and indirectly affected corporate financing. Played an important role in reducing costs. The development of the digital economy helps optimize resource allocation in the service industry. It can reduce the degree of information asymmetry, accelerate the flow of data, labor, capital and other factors, thereby improving the efficiency of resource allocation. In

addition, the development of the digital economy has also promoted the development of the service industry in a knowledge-intensive direction, transforming the service industry from a traditional labor-intensive to a technology-intensive one.

Regarding the control variables, according to the results in the table, the economic development level has a significant regression coefficient of 0.029 at the 1% significance level, which shows that with the improvement of the regional economic development level, the service industry industrial structure has been optimized and upgraded. This is because in the process of economic growth, the market system has been improved and the free flow of factors has accelerated, thus promoting the transformation and upgrading of the service industry to higher quality. The regression coefficients of the urbanization level in the model are 0.068 respectively, and they are all significant at the 1% level, reflecting a positive correlation between the urbanization level and the optimization and upgrading of the service industry structure. The improvement of the urbanization level is conducive to the manufacturing industry structure. adjustment. It shows that continuing to increase the free flow of population, coordinating the coordinated development of urban and rural areas, and optimizing the allocation of labor factors can upgrade the structure of the service industry. Utilize the economies of scale of factor aggregation and introduce high-quality resources and advanced technological concepts to provide better conditions and environment for the transformation and upgrading of the service industry.

5. Paths and Policies for Digital Economy to Drive Transformation and Upgrading of Western Service Industry

5.1. Conclusion

This article studies the theoretical mechanism of Internet popularization and digital inclusive finance on the transformation and upgrading of the service industry in the context of the digital economy. By measuring the differences in the degree of advanced service industry structure in western provinces, it is found that the uncoordinated degree of transformation and upgrading of the service industry is the main reason. Next, this paper uses the fixed effects model to conduct an empirical analysis on the panel data of prefecture-level cities in 12 western provinces for a total of 5 years from 2016 to 2020. The results show that the level of digital economy development has a significant promoting effect on the transformation and upgrading of the service industry. The popularization of the Internet has reduced internal transaction costs and information asymmetry in the service industry, while digital financial inclusion has reduced financing costs and enabled the service industry to develop in a knowledge-intensive direction. The popularization of the Internet has reduced the cost of information collection for service industry companies and consumers in terms of demand and supply, and at the same time reduced the mismatch of consumer information. With the rapid development of the digital economy, digital elements and the service industry continue to integrate and integrate with each other, enabling the optimal allocation of resources and thus realizing a new situation in the industrial structure.

5.2. Policy Recommendations

First, in order to promote the transformation and upgrading of the service industry in the western region, the government should formulate targeted policies to encourage and guide the development of digital industries in the region. Policy formulation should take into account the actual conditions of different regions. For example, in terms of Internet penetration, policies can increase Internet penetration by increasing investment and financial support in information facilities, strengthening network coverage and bandwidth and other hardware facilities. Regarding talent introduction policies, the government can encourage digital industry enterprises to develop in the western region through funds and tax incentives, and at the same time provide training and talent services. In addition, for the development of the digital service industry, the government can increase support for small and medium-sized enterprises, establish digital service industrial parks, encourage enterprises to transform and upgrade, provide more diversified digital services, and promote the coordinated development of the industry. Policy formulation should take into account regional characteristics and differences, adapt measures to local conditions, and improve the pertinence and effectiveness of policy implementation.

Second, the government should actively promote the integration and innovation of digital technology and service industry, cultivate the sharing economy and new economic growth points, provide an open environment for mass entrepreneurship and innovation, and provide strong support for the transformation and upgrading of the service industry. The government can encourage financial institutions to increase financial support for technological innovation in digital economy and service industry enterprises, and at the same time increase credit support for digital inclusive finance to service industry enterprises. In addition, the government should also build a digital empowerment platform to promote the digital transformation of traditional service industries, promote the coordinated development of all links in the service industry chain, and form a more open, inclusive, and collaborative digital ecosystem.

Third, the government should strengthen the integration of digital economy and service industry-related technologies, promote the digital transformation of traditional service industries, improve the digital level of service industry enterprises, and improve service quality and efficiency. The government can set up an innovation and entrepreneurship fund for Internet technology talents to encourage Internet technology talents to actively participate in digital transformation, promote the deep integration of the digital economy and the service industry, create a public service cloud platform for the transformation and upgrading of traditional service industries and small and medium-sized service enterprises, strengthen demonstration effects, and focus on Use multiple resources to build an innovation and entrepreneurship platform to help service industry enterprises transform and upgrade.

Fourth, the government should increase investment in the digital economy industry, solve key symbiotic issues among enterprises during the transformation of traditional industries, and achieve healthy operation of the ecosystem. The government can guide enterprises to increase investment in digital transformation, support the development of

digital economy and service industry enterprises, promote the upgrading of the digital industry, cultivate new momentum for the digital economy and service industry, and improve the "digital industrialization" level of western cities. At the same time, the government should explore new models for the development of the sharing economy, promote the development of new digital industries, pay attention to the coordinated development of the digital economy and the service industry, apply new technologies such as blockchain and quantum technology to the digital economy industry, and promote the development of the digital economy industry, innovation and upgrade.

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Carbon Emissions of Chinese Urban Households Driven by Income: 1995-2014

Dechao LIU[1], Rui GUAN[2], Yating YANG[1], Jingyi HE[1], Pengge LI[1], Rong KANG[1] and Nan LI[1*]

[1] School of Economics and Management, Northwest University, Xi'an, China; leo_dechao@163.com; yatingyang2022@163.com; 18791375709@163.com; lipengge0309@163.com; kangrong@nwu.edu.cn; linan@nuw.edu.cn

[2] Carbon neutrality college (YULIN), Northwest University, Xi'an, China; rax0695090@163.com

[*] Corresponding author: linan@nuw.edu.cn

Abstract: Over the past three decades, the rapid development of the Chinese economy has driven consumption in urban households, leading to a significant increase in indirect carbon dioxide emissions. The issue of indirect household carbon emissions has increasingly become a focal point of academic research. This paper, based on micro-level survey data of urban households, employed the input-output method to calculate indirect carbon emissions from 1995 to 2014. By utilizing the structural path decomposition method, it identified key paths contributing to carbon emissions. The results indicate that from 1995 to 2014, per capita indirect carbon emissions for Chinese urban residents increased from 1.08 tons to 7.39 tons. The multiple of indirect carbon emissions for high-income household compared to low-income household rose from 2.30 times in 1997 to 4.51 times in 2012. Carbon emissions from low-income household were primarily attributed to essential goods such as clothing and food, while high-income household's emissions were largely associated with the consumption of transportation-related goods. This paper provides insights for policymakers in developing countries seeking to reduce household carbon emissions, as the differences in carbon emissions and their driving factors among income households serve as a basis for formulating differentiated policies.

Keywords: input-output analysis; household carbon emissions; household income; structural path decomposition

JEL Classification: D10; Q50; Q56

1. Introduction

Over the past thirty years, China has experienced rapid economic development, accompanied by a substantial increase in carbon emissions. In response to the rising global temperatures, China, as the world's largest carbon dioxide emitter, has set ambitious long-term climate goals, aiming to peak carbon emissions by 2030 and achieve carbon neutrality by 2060.

Carbon emissions resulting from Chinese residents' consumption have been rapidly increasing. Household consumption has been proven to account for a significant proportion of carbon emissions in multiple countries. For example, in Canada, household carbon emissions constituted 65.62% of the national total carbon emissions in 1990 and 59.75% in 2007, while in the UK, household carbon emissions were 76% of the national total in 1997 and 77.8% in 2011

(Maraseni et al., 2015). Chinese household carbon emissions have consistently remained above 40% of the national total (Liu et al., 2011). Therefore, research on household carbon emissions is of critical importance for China in addressing climate change issues.

In 1995, the urban population in China accounted for 29.04% of the total population, and by 2014, this proportion had increased to 55.75%. The proportion of China's urban population is rapidly rising. Highlighting the significance of researching carbon emissions from urban residents in achieving China's long-term climate goals.

Carbon emissions can be roughly categorized into two types: direct carbon emissions, which result from the direct use of energy sources, and indirect carbon emissions, which stem from the use of goods or services outside of energy consumption. A notable feature of urban resident carbon emissions compared to rural resident emissions is that indirect emissions far surpass direct emissions (Liu et al., 2011; Zhang et al., 2023). Indirect carbon emissions involve numerous consumption sectors, allowing for a detailed examination of carbon emissions' specific impact on residents' consumption behavior at a more micro-level. The emission characteristics of indirect carbon emissions also differ from those of direct emissions. Consumption behavior varies among different income households, leading to variations in household carbon emissions(Wang et al., 2021). Nevertheless, research on carbon emissions based on different income households is limited, despite its crucial significance for China in developing energy-saving and emissions-reducing strategies from the perspective of domestic residents' consumption.

Hence, this paper, based on a large sample of urban resident consumption survey data, employed input-output analysis to estimate urban residents' indirect carbon emissions. It evaluated carbon emission inequality among different income households in various regions and further explored the carbon emission characteristics of different income households from macro, meso, and micro perspectives.

2. Methodology

2.1. Input-Output Model

The Input-Output model, initially proposed by Wassily Leontief, is a model used to calculate the indirect output driven by interconnections among various sectors within an economic system. In recent years, the Input-Output model has also been frequently used for calculating carbon emissions (Cao et al., 2019).Input-output tables are categorized as either competitive or non-competitive, based on whether they include foreign imports. Since this paper primarily focuses on carbon emissions from urban household consumption within one country, imported products are not considered within the scope of this paper, as their production processes occur outside the national borders. Therefore, a non-competitive input-output table is used.

The basic structure of the Input-Output model is as follows:

$$X = (I - A^d)^{-1} Y^h = LY^h \qquad (1)$$

In this context, X represents total output, I is the identity matrix, and A^d is the matrix of direct consumption coefficients excluding imported products. Y^h represents the consumption matrix of each household. L is known as the Leontief inverse matrix. When calculating carbon emissions, by introducing sector-specific direct carbon emission intensity, the model is expanded in the following form:

$$C = EX = E(I - A^d)^{-1}Y^h = ELY^h \tag{2}$$

C represents the carbon emission matrix from residents' consumption in each sector, and E represents the diagonal matrix of direct carbon emission intensity for each sector. It denotes the carbon dioxide directly emitted by sector's per unit of output.

2.2. Structural Decomposition Analysis (SDA)

This paper employs a structural decomposition analysis model to identify the impact of different factors on changes in carbon emissions. In this paper, the final demand, represented by consumption, is decomposed into the product of four factors: commodity structure matrix, consumption structure matrix, economic scale, and population scale. Therefore, the indirect carbon emissions from urban households can be expressed as:

$$C = ELY = ELDMFP \tag{3}$$

D represents the commodity structure matrix, indicating the quantity of products from sector used to satisfy the consumption of different income households. M is the consumption structure matrix, representing the structure of consumption for different income households. F and P are numerical values, representing the level of consumption and the scale of the population, respectively. SDA has multiple decomposition methods, and this paper adopts a two-level decomposition method to quantify the impact of changes in various factors on carbon emissions.

2.3. Structural Path Decomposition (SPD)

Structural path decomposition is a decomposition method based on input-output analysis, which can analyze economic changes over a period of time at the industry chain level and identify the most important influencing factors (Li et al., 2021).This paper further utilizes the SPD model to analyze the indirect carbon emissions among urban residents. The basic principle of the SPD model involves performing a Taylor decomposition on the Leontief inverse matrix L. Substituting the Leontief inverse matrix L, after the Taylor decomposition, into Equation (3) transforms the original equation as:

$$C = ELY = EDMFP + EADMFP + EA^2DMFP + \cdots \tag{4}$$

The first term represents the carbon emissions induced by the first-order industrial chain, which reflects consumers' direct demand for a product from a specific sector. The second term represents the carbon emissions induced by the second-order industrial chain, which involves passing through an intermediate sector before reaching consumers. This reflects the indirect demand generated by consumers' demand for a product from one sector on another sector.

Similarly, the third-order industrial chain refers to the industry chain that has passed through two intermediate sectors. This decomposition can continue indefinitely, representing the carbon emissions brought about by an (n+1)-order industrial chain. Based on previous research findings, this paper selects the first three-order industrial chains for analysis. The carbon emissions, after introducing the Taylor decomposition into the Leontief inverse matrix, can be expressed as:

$$
\begin{aligned}
\Delta C = \Delta C^{E1} + \Delta C^{D1} + \Delta C^{M1} + \Delta C^{F1} + \Delta C^{P1} + \Delta C^{E2} + \Delta C^{A2} + \Delta C^{D2} + \Delta C^{M2} \\
+ \Delta C^{F2} + \Delta C^{P2} + \Delta C^{E3} + \Delta C^{A3} + \Delta C^{D3} + \Delta C^{M3} + \Delta C^{F3} \\
+ \Delta C^{P3} + \cdots
\end{aligned}
\tag{5}
$$

The first to fifth terms represent the first-order effects of carbon dioxide emissions, the sixth to eleventh terms represent the second-order effects of carbon dioxide emissions, and the twelfth to eighteenth terms represent the third-order effects of carbon dioxide emissions. The superscript for each term indicates its inducing factor and the order of the industrial chain to which it belongs.

2.4. Data Processing

The direct carbon emissions intensity of each sector for each year is derived from the fuel consumption, the direct emission coefficients of the fuels used, and the output of each sector from 1995 to 2014. The types of fuels and their respective quantities consumed by each sector are referenced from the China Emission Accounts and Datasets (CEAD) subnational carbon emission inventory (CEADs, n.d.). The direct emission coefficients of the fuels are calculated based on the China Energy Statistical Yearbook and the Greenhouse Gas Inventory Guide. The output data for each sector is obtained from the input-output tables.

The input-output table data and trade data in this paper are sourced from the official input-output tables published by the Chinese government. In years when the government did not publish input-output tables, the data used in this paper were obtained by averaging weighted input-output data from nearby years.

The household consumption and income data used in this paper are sourced from the China Urban Household Survey (UHS). This paper uses a portion of the UHS dataset from 1995 to 2014. As the consumption categories in household consumption data do not align precisely with the sector classifications in the input-output table, this paper combines household consumption sectors and input-output sectors into 29 mutually matched sectors, following previous studies (Golley & Meng, 2012; Zhang et al., 2023) and Chinese industry classification standards. Urban population data are calculated based on census data provided by the National Bureau of Statistics of China.

The data used in this paper is from non-public micro-level survey data. The paper has made efforts to obtain data up to 2014. However, due to the complexity and intricacy of household data surveys, the data has not been updated beyond 2014.Although the household carbon emission results calculated in this paper are only up to 2014 due to the lack of updated data, there may be some discrepancies with the current household carbon emission trends. However, this paper tracks the long-term trends of Chinese household carbon emissions from

a micro perspective. The paper uses non-public household survey data from UHS, which is difficult to obtain. Because of the detailed survey items, the calculated results in this paper are more accurate and can better reflect the characteristics of household carbon emissions compared to calculations directly based on macro data. Furthermore, compared to short-term changes, this paper focuses on studying the long-term trends from 1995 to 2014, spanning twenty years. Long-term studies can capture more trends that cannot be discovered in short-term studies, and long-term trends are also of greater concern to policymakers.

3. Results

3.1. Main Result

According to equation (2), the variation in per household carbon emissions in China from 1995 to 2014 was calculated. In 1995, the per household indirect carbon emissions for urban households in China were 1.08 tons, increasing to 7.39 tons in 2014, a growth of 6.83 times compared to the original value. The carbon emissions from Chinese household consumption have consistently been in a phase of steady increase.

Combining data on the number of urban households in China, this paper estimated the total indirect carbon emissions from urban households. The calculation results show that in 1995, China's total indirect carbon emissions from urban households amounted to 10,257.35 million tons, increasing to 190,966.72 million tons in 2014. Carbon emissions grew by 1,861.76% during these two decades, with an average annual growth rate of 19.21%.
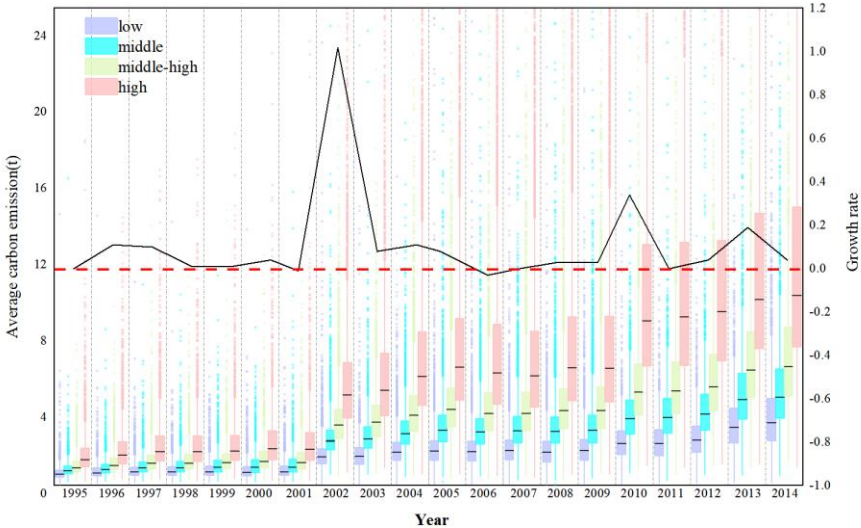
Figure 1. Average household carbon emissions by income and year. (The top 25% of the total population represents high-income, while the 25% to 50% range corresponds to middle-high-income households, and so on)

Analyzing different income households, we categorized the urban population into four income households based on their annual income and plotted the corresponding per capita carbon emission coefficients in a line chart, as shown in Figure (1). The carbon emissions for the highest-income household increased from 2.48 times that of the low-income household in 1995, 1.98 times for the middle-income household, and 1.61 times for the middle-high income

household. By 2010, these ratios had risen to 4.82 times, 2.99 times, and 2.08 times, respectively. By 2014, there was a slight reduction, with ratios of 3.4 times for the low-income household, 2.49 times for the middle-income household, and 1.81 times for the middle-high income household. From 1995 to 2014, the proportion of total emissions in China attributable to high-income household increased from 39% to 45%, while the carbon emissions share of low-income household decreased from 16% to 13%. It is evident that there are significant disparities in carbon emissions among different income household, and this inequality has become more pronounced over time.

Based on the proportion of different income household in various regions in the sample and the corresponding per capita indirect carbon emissions, the total proportion of indirect carbon emissions from household in different income household in each region can be calculated. As shown in Figure (2), the average household carbon emissions in the southeast coastal region are consistently higher than those in the northwest inland region, and the East China and South China regions always have the highest per capita carbon emissions in China. The proportion of carbon emissions from high-income household is strongly positively correlated with the regional average carbon emissions. In the two regions with the highest per capita carbon emissions in China—East China and South China—high-income household carbon emissions account for over 70%, indicating that high-income household are the main driving force behind carbon emissions. This is partly because the average carbon emissions of high-income household in the southeast coastal region are higher than those in the inland region, and another reason is that high-income individuals are mainly concentrated in the southeast coastal region. An apparent exception seems to be the North China region, which exhibits high carbon emissions that do not align with its geographical characteristics. A reasonable explanation is that China's capital, Beijing, is included in the North China region, and the proportion of high-income household in Beijing is higher than in other provinces in the North China region.
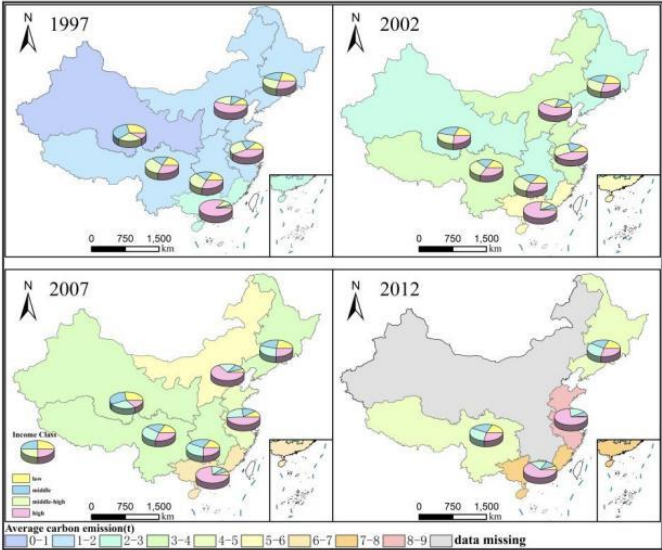
Figure 2. The distribution of total carbon emissions from households with different incomes in different regions and the average carbon emissions in different regions. The pie chart represents the total carbon emissions, and the colors in different regions represent different average carbon emissions (the data in North China, Central China and Northwest China are lacking in 2012)

3.2. Decomposition Analysis

To further decompose the impact of various factors on carbon emissions, this paper investigated the changes in carbon emissions from 1997 to 2012. This period was divided into three segments: 1997-2002, 2002-2007, and 2007-2012. Structural decomposition analysis and structural path decomposition were employed to break down the changes in household indirect carbon emissions during these three periods. The decomposition results were analyzed at both macro, meso and micro levels.

According to equations (3), the changes in carbon emissions can be decomposed. The decomposition results are shown in Figure 3. At the macro level, the effects of consumption scale, population scale, commodity structure, and consumption structure have all contributed to the increase in carbon emissions from urban residents in China to a certain extent.

Regardless of the time period, the consumption scale effect remains the largest driving force behind the increase in carbon emissions from urban residents in China. This trend is continuously expanding: the contribution of the consumption scale effect to urban resident carbon emissions in China increased from 102.48% in 1997-2002 to 117.69% in 2002-2007 and further to 128.58% in 2007-2012. The increase in carbon emissions due to the population scale effect is also significant, rising from 27.29% in 1997-2002 to 53.26% in 2002-2007 and then to 37.91% in 2007-2012. This reflects both a substantial increase in the consumption capacity of urban residents and a significant increase in their population.
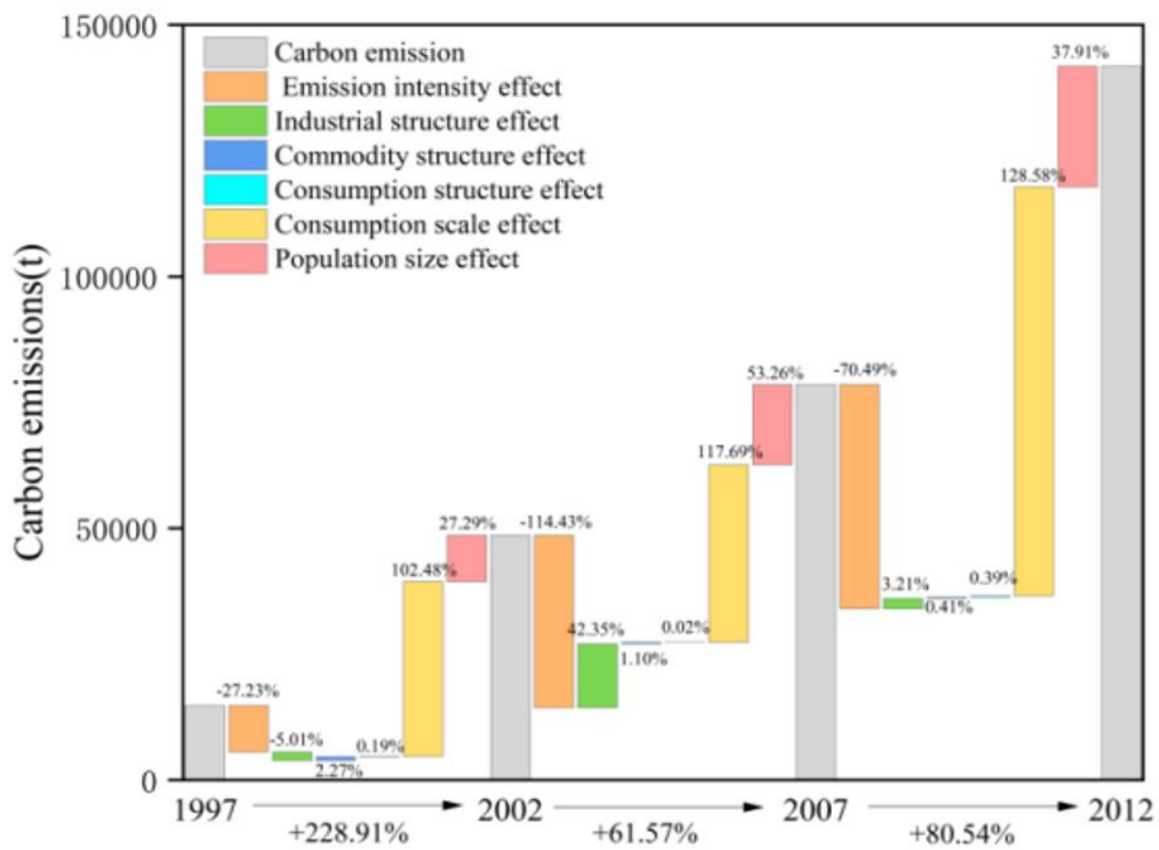
Figure 3. Changes and driving factors of indirect carbon emissions from urban household from 1997 to 2012. The structural decomposition analysis and structural path decomposition were used to analyze the changes of indirect household carbon emissions in three periods

The industrial structure effect initially showed a trend of reducing carbon emissions from urban residents in China, with a reduction contribution of 5.01% in 1997-2002. However, in the subsequent periods of 2002-2007 and 2007-2012, it exhibited a trend of increasing carbon emissions. In the 2002-2007 period, it even contributed 42.35% to the net increase in carbon emissions in China, reflecting the reality of China's overall shift in industrial structure towards the manufacturing of high-carbon-emission products after 2002.

The carbon emission intensity effect has been the primary driver of carbon reduction in China, showing a strong trend of reducing carbon emissions from urban residents during all three periods, with reduction contributions of 27.23%, 114.43%, and 70.49% respectively. Especially in the 2002-2007 period, the contribution of emission intensity to carbon reduction almost offset the increase in carbon emissions due to the expansion of consumption scale, demonstrating the continuous improvement of China's industrial technology and the greener nature of its technology.

According to formulas (4), the order of urban residents' consumption goods can be obtained. The calculation results show that the newly added carbon emissions come predominantly from the first, second, and third-order industrial chains, accounting for 79%, 61%, and 70% respectively. Therefore, it can be considered that the first three orders are the main components of urban residents' consumption. In our subsequent research, we mainly analyze the carbon emissions characteristics caused by the first three-order industrial chains. As the order of the industrial chain increases, the corresponding products result in less carbon emissions in urban residents' consumption. This indicates that consumer goods for urban residents are different from the complex products required for industrial manufacturing, and shorter-order simple products are the main objects of consumption for urban residents.

Based on the frequency of being among the top ten in carbon emissions or reductions in each period, this paper identifies key industry chains in the first, second, and third-order: these industry chains play a crucial role in both carbon emissions and reductions. Over three periods, the key sectors in the first order industry chain are food and tobacco processing manufacturing, chemical industry, and electricity, heat production, and supply. In the second order industry chain, the most important one is the chemical industry to chemical industry chain, followed by the agriculture, forestry, animal husbandry, and fishery to food and tobacco processing manufacturing chain. The chain from non-metallic mineral products industry to construction and from petroleum and natural gas extraction to petroleum processing and coking industry is in the third place. In the third order industry chain, the chemical industry to chemical industry to chemical industry holds the most crucial position, followed by agriculture, forestry, animal husbandry, and fishery to agriculture, forestry, animal husbandry, and fishery to food and tobacco processing manufacturing. Petroleum and natural gas extraction to petroleum and natural gas extraction to petroleum processing and coking industry ranks third. It can be observed that the chemical industry and food and tobacco processing manufacturing play important roles, and some sectors exhibit clear self-circulation phenomena, such as the chemical industry, agriculture, forestry, animal husbandry, and fishery, and petroleum and natural gas extraction.

To gain a deeper understanding of the specific industrial chain's carbon emissions and its driving factors, this paper conducted structural path decomposition of urban residents' indirect carbon emissions in three time periods: 1997-2002, 2002-2007, and 2007-2012, based on formula (5). It identified the thirty key paths contributing to the growth or reduction of carbon emissions for urban residents in China during these periods.

From an industrial chain perspective, the industry chain with the highest carbon emissions increase in China from 1997-2002 was the chain from chemical industry to high-income household, with a net emission of 1,105.93 million tons of carbon dioxide. In 2002-2007, it was the chain from transportation, warehousing, and postal services to high-income household, with a net emission of 685.68 million tons of carbon dioxide. In 2007-2012, it was the chain from petroleum processing and coking to high-income household, with a net emission of 2,489.54 million tons of carbon dioxide. From a carbon reduction perspective, the most significant chain from 1997-2002 was the chain from chemical industry to textile industry to chemical industry again to high-income household, with a net reduction of 1.98 million tons of carbon dioxide. In 2002-2007, it was the chain from electricity, heat production, and supply to high-income household, with a net reduction of 197.06 million tons of carbon dioxide. In 2007-2012, it was the chain from gas production and supply to high-income household, with a net reduction of 72.83 million tons of carbon dioxide. Urban residents' indirect carbon emissions generally have short orders.

There are key sectors in the key paths of urban residents' indirect carbon emissions. From 1997-2002, eight paths involved food and tobacco processing, accounting for 9.99% of the total increase in household indirect carbon emissions. In 2007-2012, six paths involving S6 remained, accounting for 8.56%, seven paths involving the chemical industry accounted for 9.7%, and seven paths involving petroleum processing and coking accounted for 9.45%. This reflects changes in the consumption goods structure of urban residents in China, where the key components of food and tobacco processing are various processed foods, and the key components of petroleum processing and coking are expenses related to fuel and transportation.

The consumption scale effect remains the most important factor contributing to the increase in carbon emissions, accounting for 73.53%, 72.74%, and 71.31% of the total change in carbon emissions for the thirty key paths during the periods 1997-2002, 2002-2007, and 2007-2012 respectively. The commodity structure effect and population scale effect are also important factors contributing to carbon emission increases. The ratio of the commodity structure effect to the total change in carbon emissions for the thirty key paths is 9.56%, 6.17%, and 12.21% for the three time periods, while the population scale effect is 6.93%, 18.79%, and 7.72%.

From 1997-2002, high-income household accounted for 16 out of the thirty key paths, contributing 54.07% to the total change in carbon emissions and 14.71% to the total increase. From 2007-2012, high-income household occupied 19 out of the thirty key paths, contributing 65.42% to the total change in carbon emissions and 24.96% to the total increase. The proportion of carbon emissions attributed to high-income household is not proportional to their population, and this ratio tends to expand over time.

The most significant driver of carbon reduction for urban residents in China is the emission intensity effect, accounting for 62.87%, 98.28%, and 88.08% of the total reduction for the thirty key paths during the periods 1997-2002, 2002-2007, and 2007-2012 respectively. The reduction from the commodity structure effect is relatively small, accounting for 29.84% of the total reduction for the thirty key paths in 1997-2002 and 11.9% in 2007-2012. Food and tobacco processing, chemical industry, electricity and heat production, and petroleum processing and coking play important roles in carbon reduction.

High-income household bear a much higher responsibility for carbon emission increases in China than low-income household. In 2007-2012, the industry chain with the highest emission increase for high-income household was the chain from petroleum processing and coking to high-income household, with a net increase of 2,489.54 million tons of carbon dioxide. The chain with the highest emission increase for low-income household was the chain from chemical industry to low-income household, with a net increase of 314.76 million tons of carbon dioxide. The former is 7.9 times the latter. The chain with the most reduction for high-income household was the chain from gas production and supply to high-income household, with a net reduction of 72.83 million tons of carbon dioxide. The chain with the most reduction for low-income household was the chain from coal mining and washing to low-income household, with a net reduction of 34.74 million tons of carbon dioxide. The former is only 2.09 times the latter.

4. Discussion

The research results of this paper confirm the existence of differences in carbon emissions among household with different income levels, and these differences have further widened over time. The majority of urban household carbon emissions are caused by affluent families: over 69% of urban household carbon emissions come from affluent families. From 1995 to 2014, the proportion of emissions from high-income families, representing 25% of the total population, increased from 39% to 45%, while the carbon emissions share of low-income household, also representing 25% of the total population, decreased from 16% to 13%. The research results also indicate that these differences are more pronounced in the southeastern coastal regions of China. These differences are evidently associated with regional disparities, as carbon emissions in households from the southeast coastal regions are significantly higher than those in the less developed northwest inland areas, with variations among different income households being greater in coastal regions than inland areas.

The paper also identifies key drivers influencing carbon emissions and reductions, confirming that the disparity in carbon emissions is associated with the consumption patterns of household with different incomes. The increase in consumption scale resulting from rising household income contributes to a significant surge in urban household carbon emissions, while the decrease in emission intensity due to technological advancements is the main driver of carbon emission reduction. Urban household carbon emissions primarily stem from the consumption of low-tier industrial chain goods, especially those in the first-tier industrial chain. Through structural path decomposition, based on different orders of the industrial chain,

the paper identifies key industrial chains that are significant for carbon emissions, some of which exhibit obvious self-circulation phenomena. Food and tobacco processing industry, chemical industry, petroleum processing and coking industry, and electricity, heat production, and supply industry are key sectors for urban household carbon emissions. High-income families tend to consume goods related to transportation and fuel, which result in more carbon emissions compared to the goods purchased by low-income families such as food and textiles. High-income families play important roles in both carbon emissions and reductions, but the carbon emissions caused by high-income families are much higher than their reduced carbon emissions.

The research reveals characteristics of carbon emissions in Chinese households, including regional, income, and commodity distribution features, providing insights for the formulation of relevant carbon reduction policies in China. The increase in urban consumption scale and population growth is inevitable in the future. Therefore, in addition to developing green technologies to reduce carbon emissions, urban household carbon reduction will depend on changes in industrial structure, income structure, and consumption structure. Government-specified policies can influence these factors. Firstly, carbon reduction policies in China should distinguish between the southeast coastal region and the northwest inland region, taking into account the economic development level differences, especially in carbon reduction policies designated from the consumption end. Secondly, when formulating consumption-side carbon reduction policies, the government should be aware of the importance of carbon emission transmission between different sectors. High carbon emissions in consumer goods are likely caused by a high carbon-emitting sector in the consumer goods industry chain. Therefore, carbon reduction policies should focus on these crucial sectors, using key nodes in each industry chain to promote energy-saving and emission reduction in China's overall industrial structure. For example, in recent years, petroleum processing and coking industry have become the main sectors for household carbon emissions. Targeted policies should be developed to achieve coordinated carbon reduction in various sectors while ensuring stable economic development. Thirdly, residents' final demand remains the driving force for household carbon emissions. To control the increase in household carbon emissions and narrow the carbon emission gap between different income households, the government should formulate differentiated consumption-side policies based on the consumption patterns of households with different income levels. Urban household carbon emissions mostly come from high-income families, and consumption related to transportation has become the largest source of carbon emissions for high-income families. Advocating for environmentally friendly modes of transportation is a crucial direction for promoting urban household carbon reduction. Encouraging non-motorized transportation, public transportation, and shared transportation, imposing higher taxes on environmentally polluting fuels, and levying higher taxes on cars, especially luxury cars favored by high-income families, can effectively promote urban household carbon reduction. Additionally, implementing income redistribution systems from high-income families to low-income families and advocating for a green lifestyle are also crucial.

High-income households evidently contribute more to carbon emissions, but it must be acknowledged that the drivers of socioeconomic development and predominant consumers are often high-income families. If carbon reduction policies are selectively targeted at high-income households, it is bound to have an impact on economic development. Striking a balance between economic development and environmental protection will be a major challenge for policymakers.

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development. Simancas Cruz and Peñarrubia Zaragoza (2019) studied the spatial distribution of tourist flows to identify overcrowded areas. The basic stages of such studies were developed over a number of years by Russo (2002) and they can be used for decision-making in favour of sustainable development. The development of tourism in UNESCO sites is greatly influenced by the image of the attraction (Gabdrakhmanov et al., 2020) or even the country. This image is formed by the overall impression and intention to make a return visit and recommend the tourist sites to other tourists.

Ryan and Silvanto (2009) pointed out that while inclusion in the UNESCO World Heritage List is a privilege, it also brings with it responsibilities and commitments. The authors identified and described the factors that contribute to the maintenance and development of these sites, which are important elements in the formation of attractiveness. The branding of UNESCO sites has its own specifics. To maintain the attractiveness of these sites, it is necessary to understand the motives that lead to visits (Ramires et al., 2018). It is necessary to constantly carry out research, as the characteristics of visitors and their motives change.

The organization of tourism at UNESCO sites requires knowledge of the strengths and weaknesses. It requires cooperation at local, regional, national and international levels. The involvement of stakeholders in the process of tourism development at UNESCO sites varies from country to country. Li et al. (2020) reported that interest groups in China are highly dependent on the government. The researchers noted that UNESCO sites and interested parties in tourism development need to build cooperation on the principles of partnership, delineating the degree of responsibility, rights and obligations.

There is no doubt that the assignment of UNESCO status contributes to the development of the area and changes the lives of local people. The perception of these changes by local residents has been the subject of research by many scientists, such as Gullino et al. (2020). The researchers concluded that it is necessary to maintain the value of the UNESCO site. The involvement of the local population in decision-making and the development of such areas is an integral part of the development of tourism at these sites.

The attractiveness of a country is determined by various factors. One of them is the availability of cultural heritage and UNESCO sites. The appeal of these sites is constantly changing due to various circumstances. Visitor numbers are influenced by the image of the country, the region, as well as the political situation, accessibility, the entrance fee, and other factors. A special factor that had a significant impact on the development of tourism was the COVID-19 pandemic. During this period, the flow of tourists and the operation of UNESCO sites changed significantly.

The aim of this paper is to demonstrate and evaluate the impacts of the global pandemic SARS COV-2 on the visitation of UNESCO sites in the Czech Republic.

development at UNESCO sites but does not take into account the impact of factors caused by the SARS COV-2 pandemic.

Pérez-Calderón et al. (2024) studied UNESCO geoparks in protected areas in Spain. They found stronger perceptions of sustainable development in geoparks than in national parks. This approach indicates a very strict regulation of protected areas, which may be detrimental to tourism development and the quality of life of the population. However, the study is limited to the impact of factors on UNESCO natural sites and does not consider the impact of the SARS COV-2 pandemic on cultural sites.

Medeiros et al. (2024) studied natural UNESCO sites in Portugal according to physical, aesthetic and psychophysical attributes. This approach is useful for identifying priority measures and monitoring landscape evolution over time. However, it does not include the study of cultural sites and the impact of SARS COV-2 on these attractions.

UNESCO natural monuments have also been studied by Spanish scientists Gavilan et al. (2024), who demonstrated the benefits of digitisation for the development of UNESCO heritage sites. This approach identified critical factors for the development of UNESCO natural sites without taking into account the impact of these factors on cultural sites.

The accessibility of UNESCO sites for people with disabilities in Spain was investigated by Elorduy and Gento (2024). These researchers identified the existing barriers that people with disabilities encounter when visiting UNESCO sites in Spain. This approach highlights the impact of public transport accessibility on the number of visitors to UNESCO sites from different segments of the population, including people with disabilities.

Czech scientists have contributed significantly to the study of tourism development by investigating the tourism potential of UNESCO sites.

Burda et al. (2023) investigated the convenience of using various modes of transport, including public transport, to reach tourist attractions in the Czech Republic. The researchers demonstrated the existing problems in the availability of public transport services caused by the difficulty of accessing some tourist sites in the Czech Republic, including UNESCO sites, due to their location in remote areas, among other factors. This method of examining the relationship between the volume of public transport and the rise in the number of tourists visiting particular tourist destinations—like Český Krumlov, Janské Lázně, and Lednice—does not fully capture the extent of the SARS COV-2 pandemic's effects on all UNESCO sites in the Czech Republic and might require further research.

Kvítková and Petrů (2023) investigated UNESCO cultural heritage sites during SARS COV-2. The researchers identified that the number of visitors to UNESCO sites is influenced by a variety of factors, including visitor structure (foreign and domestic), location, accessibility, seasonality, and regional significance. This study makes a contribution by demonstrating that UNESCO listing was more of a disadvantage in the first year of the pandemic (2020), which reduced visitor numbers to the sites. UNESCO listing was a drawback because the decline was more pronounced at UNESCO sites due to their higher visitor numbers. This method does not account for factors such as transport utilisation or visitor motivations between their segmentation during the SARS COV-2 period and after.

Pachrová et al. (2018) investigated differences in tourist demand for UNESCO sites in the Czech Republic. The study hypothesised that visiting UNESCO sites in the Czech Republic draws day visitors. This approach is useful for managing tourist sites and developing individual tourism development strategies, but it highlights a number of issues caused by day tourists.

As previous research suggests, changes in tourist demand for UNESCO sites are also affected by factors other than SARS COV-2, such as tourists' preferences and wishes. This is due, among other things, to the increased use of digital technologies in tourism, which occurred particularly during the SARS COV-2 and post-COVID periods. Furthermore, the current study provides a comprehensive picture of tourist demand for UNESCO heritage, which is relevant to the Czech Republic's regional policy.

According to But et al.'s (2023) research, the most appealing cities for Czech tourists are smart cities, which are mobile (everything important to tourists will be available on mobile devices), data-driven (using big data for better management), and friendly and fun (thanks to advanced navigation, entertainment, and information for tourists). This approach will generally increase the tourist appeal of UNESCO sites in the Czech Republic, as the implementation of digital network standards stabilises and secures the tourist infrastructure. At the same time, the impacts of social, technological, environmental, and management conditions, as well as the SARS COV-2 pandemic, must be considered.

Further research on visitor numbers to UNESCO sites was carried out in 2023, analysing admission prices to UNESCO sites and visitor numbers before and after the SARS COV-2 period (Lněnička et al., 2023).

The above theoretical and practical research is a prerequisite for determining the impact of the SARS COV-2 pandemic on individual UNESCO sites in the Czech Republic.

2. Methodology

The authors purposefully focused their research on the effects of the SARS COV-2 pandemic in the Czech Republic on UNESCO sites. These sites suffer the most from visitor loss as a result of the pandemic's closures or restrictions on operations. Another important factor limiting tourism is national legislation or regulations (Act No. 185/2020 on certain measures to mitigate the impact of the SARS CoV-2 epidemic on tourism), which restrict or even prohibit travel and visits to heritage sites. Sixteen UNESCO sites in the Czech Republic were selected as model sites for the study. The monuments' locations are shown on the map in Figure 1. These are the monuments that UNESCO had listed as of March 31, 2023, when the questionnaire survey was launched. In September 2023, at its 45th extended session in Riyadh, the World Heritage Committee decided to include another Czech site on the UNESCO World Heritage List: Žatec and the Žatec Hop Landscape (UNESCO World heritage convention, 2024). However, this monument was not the subject of the research in 2023.

Figure 1. UNESCO Czech heritage (own processing based on ARCDATA (2023))

The overall goal of the study is to assess the impact of the SARS COV-2 pandemic on specific UNESCO sites in the Czech Republic. The evaluation is carried out using both analytical (data collection and analysis) and synthetic methods (measure proposals and recommendations). The main objectives are supplemented by specific objectives:

- Gathering primary data on the number of visitors to UNESCO sites in the Czech Republic;
- A comparison of visitor statistics for 2019 and 2022;
- Creating a set/catalogue of measures based on the main areas analysed from the questionnaire survey results.

This paper does not intend to go into detail regarding all methods, but we can highlight the most important one, namely the qualitative method of sociological research. The authors drew on many years of experience and knowledge from previous studies conducted as part of basic and applied research projects at the UHK (University of Hradec Králové), UK (Charles University in Prague), and MUNI (Masaryk University in Brno). The entire research is divided into three years, so the paper only presents the findings from the first stage.

The research was conducted from March until the end of September 2023. The target group of the research included visitors to the UNESCO Heritage Sites regardless of their place of residence. The selection of respondents was based on random sampling, taking into account the size of the baseline sample, i.e. all visitors to UNESCO sites in 2021 during the tourist season (almost 3 million visitors). The respondents had the opportunity to fill in the questionnaire in physical form at the ticket offices and information centres of the selected UNESCO sites, electronically in the Survio app directly from the link or using a QR code. Information about the survey was published monthly in the newsletter of the Czech UNESCO Heritage portal. The questionnaires were physically available at the ticket offices

of individual sites, tourist information centres and other places where entrance fees were paid (e.g. Villa Tugendhat in Brno, Cathedral of the Assumption of the Virgin Mary in Sedlec).

After the questionnaire collection had been completed, the evaluation phase began. All 16 monuments participated in the survey, but in different ways. For example, the historical center of Prague or the state castle Valtice were not represented due to the refusal of the information centre staff and the castle administration. Overall, 377 completed questionnaires were received (218 physically and 159 electronically), which is a relatively small number compared to the total number of visitors. After conducting an initial assessment, sixteen questionnaires were discarded due to their incorrect and incomplete completion, and lack of direct focus on UNESCO sites in the Czech Republic. Frequently, incorrect names of sites appeared (e.g. Karlštejn Castle, Hluboká nad Vltavou Castle or the Krkonoše). These destinations are not part of UNESCO cities. After the initial selection, the sample comprised of 218 questionnaires that were physically submitted and 143 ones that were electronically submitted, resulting in a total of 361 respondents (Table 1). In terms of gender, 56% of the sample was female, 43.9% male and 0.1% non-gender respondents. Unfortunately, some places were not enough to fill out any questionnaires. The questionnaire data were processed in digital form and analysed using the statistical program IBM SPSS Statistics ver. 29. In addition to descriptive statistics, the analysis of variance (ANOVA) method was used to identify differences in the perception of positive and negative impacts between different groups and correlation analysis was used to identify significant factors influencing the perceptions and attitudes of residents. The statistical error for the sample size (n = 361) is +/- 5%.

Table 1. Number of respondents by survey

UNESCO monument	City/town	Region	Nr. of Respondents	
			Physical	On-line
Villa Tugendhat	Brno	South Moravia	15	1
Historical Town Centre	Český Krumlov	South Bohemia	5	31
Historic Village	Holašovice	South Bohemia	-	-
The Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe	-	Liberec	-	1
The landscape for Breeding and Training of Ceremonial Carriage Horses	Kladruby nad Labem	Pardubice	5	1
Gardens and Castle	Kroměříž	Zlín	15	7
Erzgebirge/Krušnohoří Mining Region	-	Karlovy Vary, Ústí nad Labem	38	6
Historical Town Centre with the Church of St Barbara and the Cathedral of Our Lady at Sedlec	Kutná Hora	Central Bohemia	1	19
Great Spa Towns of Europe (in Czechia: Karlovy Vary, Mariánské Lázně and Františkovy Lázně)	-	Karlovy Vary	84	2
Cultural Landscape	Lednice, Valtice	South Moravia	2	21
Castle	Litomyšl	Pardubice	11	8
Holy Trinity Column	Olomouc	Olomouc	6	5
City Centre + Průhonice Park	Praha	Praha	-	5
Historical Town Centre	Telč	Vysočina	29	17
Jewish Quarter and St Procopius' Basilica	Třebíč	Vysočina	3	11
Pilgrimage Church of St John of Nepomuk at Zelená Hora	Žďár nad Sázavou	Vysočina	4	8
Total			218	143

Parallel to the questionnaire survey, a survey of the number of visitors to UNESCO sites was carried out. Using statistical data and subsequent telephone follow-up, a database of visitor numbers to the sites in 2019 and 2021 was compiled. Additionally, data were collected on admission prices to the sites in 2019 and 2022.

3. Results

This chapter presents selected outcomes of the questionnaire survey. The questionnaire included seventeen questions and three additional geodemographic questions. It was deliberately distributed only in the Czech language, and the question regarding the respondents' geographic origin confirmed their Czech origin, among other things. Most respondents arrived at the UNESCO sites from the Czech Republic, specifically from Bohemia (33.6%) and from Moravia (30.4%) There were only 8.8% of foreign respondents, most of them from Slovakia. Although the questionnaire was in Czech, six other foreign respondents were able to complete it. However, these may be foreign visitors who have
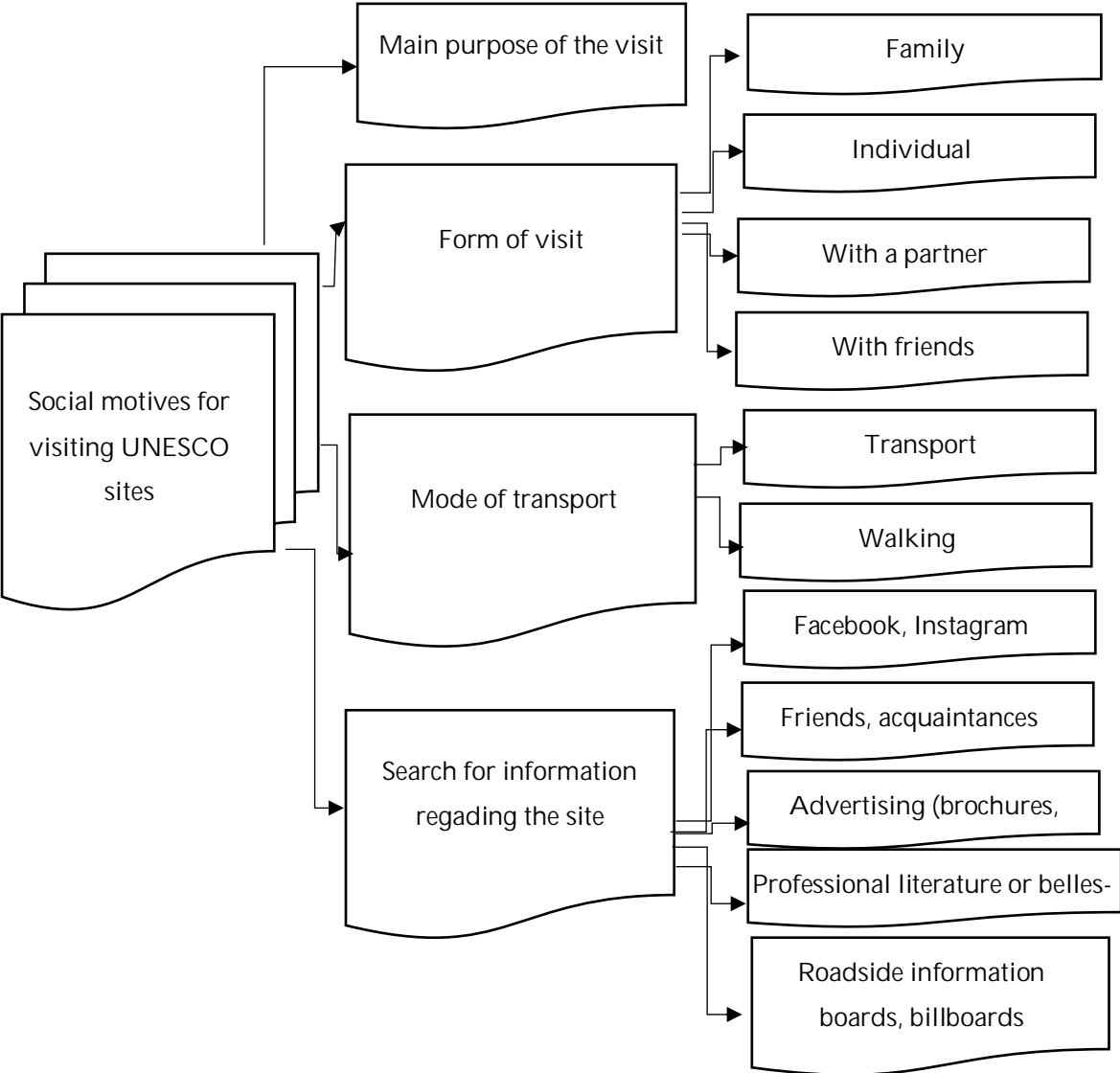
Figure 2. The social motives for visiting UNESCO sites

Czech roots, but who have been living outside the Czech Republic for a long time. Other group of respondents (8.4%) came from the vicinity or from the same region where the UNESCO site is located.

3.1. Social Motives for Visiting a UNESCO Site

The social motives for visiting UNESCO sites are shown in Figure 2 above.

In the first section of the questionnaire, the research wanted to determine the main purpose of the visit to the UNESCO site, the form of the visit, and the mode of transport used by the visitors. These were questions with a choice of just one of the options offered. From the results obtained, it is not surprising that the main purpose of visiting a UNESCO site is interest in history, architecture, and UNESCO sites (stated by 52% of respondents) Most sites have a historical context, and the purpose of protection lies in their historical and architectural value. Another purpose mentioned is the pursuit of recreation, sport, culture (21.1%), and interest in natural attractions (10.8 %). These responses were particularly evident among respondents who had visited a site that featured a significant landscape component, specifically the Lednice-Valtice Area, the Erzgebirge, and the Jizera Mountains. To a lesser extent, responses such as visiting relatives or friends (4.4%) and other unspecified purposes (8.2%) were also identified.

The second part focused on the form of the visit. This question was purposefully asked to find out whether visitors travel individually or in a group. The highest representation was found in the categories of travelling with family (44.4%) and individual or with a partner (36.3%). These were mostly visits to historic monuments, historical centres, and spa towns. The third most representative answer was travelling with friends (11.1%) This category was more represented in the case of natural monuments, such as the Lednice–Valtice Area and the Erzgebirge. A mere 2% of the respondents reported an organized visit by a travel agent or agency.

An interesting question was directed to the mode of transport to the site. The respondents had a choice of nine options, from car to walking (see Figure 3). 44.7% of the respondents opted for the car as their mode of transport. Therefore, it is an individual mode of transport that is associated with convenient transportation to the monument. The typological distribution indicates that more visitors travel by car to historic and architectural monuments. They assume that there is a good parking option with accompanying facilities, such as guarded parking. The second preferred transport option was personal transport by caravan, with 26.3%. However, in response to question no. 9 (Describe three things you would do to improve (change, renovate, make more attractive) the UNESCO site and its administrative area), respondents were dissatisfied, even outright critical of the parking facilities. Among respondents, the most used modes of transport were the train (9.4%), bus (6.4%) and collective tour coach (3.5%). According to the survey, 6.4% of respondents accessed the monument on foot.
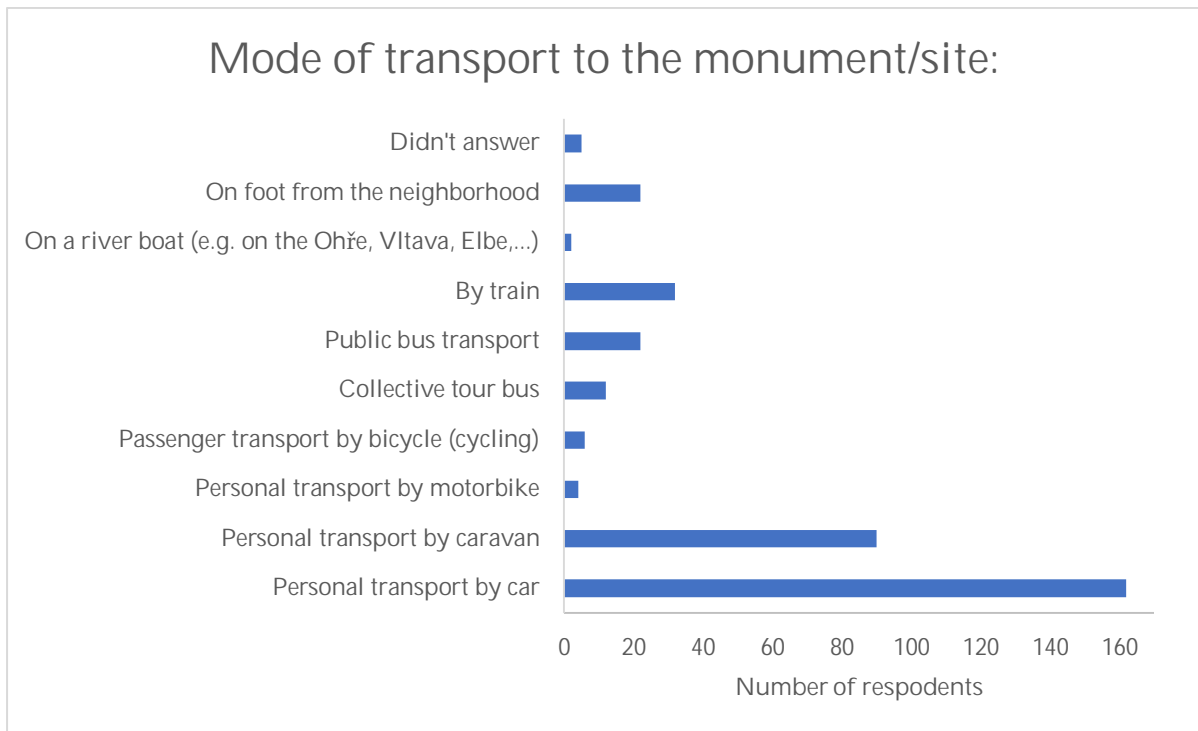
Figure 3. Mode of transport to the monument/site

The final question in this section was related to finding out about the awareness of the UNESCO site, i.e. from which sources visitors learned about the site. The results indicated that electronic media (web, Facebook, Instagram, etc.) dominated the list – 30.1%. Since access to these types of media is now commonplace, the results were not surprising. Another source of information (20.5%) was the personal knowledge of friends and acquaintances. Print media, particularly leaflets, brochures, and other similar materials, also play a significant role. 12% of respondents reported receiving information from printed promotional materials, while another 7.9% of respondents obtained information from professional literature or belles-lettres. Other sources of information include information boards and orientation systems, most often found in towns or on important roads of class I and II. This option, which is available from information boards located in nearby towns and roadsides, was mentioned by 3.8% of respondents.
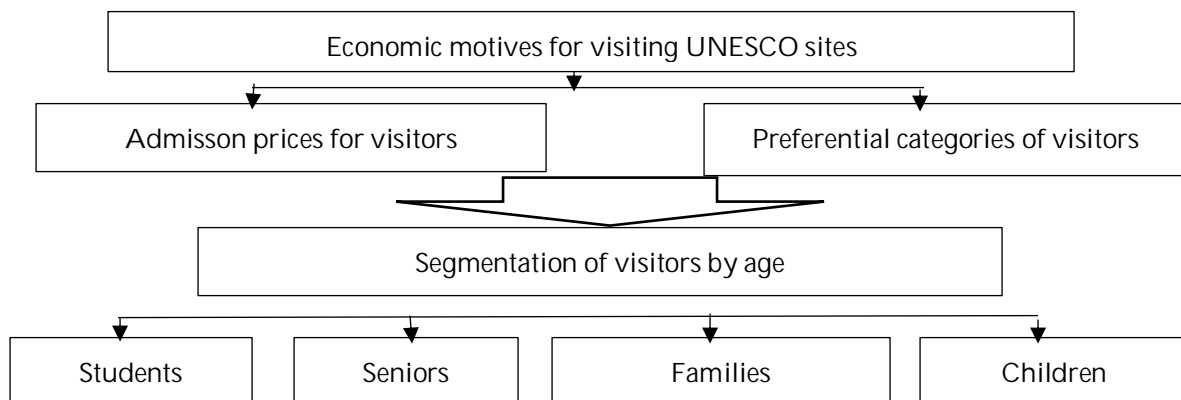
Figure 4. The impact of economic motives on visitor numbers to UNESCO sites

3.2. Economic Motives for Visiting UNESCO Sites

The impact of economic motives on visitor numbers to UNESCO sites is shown in Figure 4.

Figure 4 shows that for many visitors the economic aspect, namely financial (ability to pay), can also be a reason to visit a tourist attraction. The interruption of the tourist season and the closure of monuments in 2020 due to the declaration of a state of emergency in the Czech Republic (Resolution No. 69/2020 Coll.) and the adoption of legislative measures (e.g. Act No. 247/2020 Coll, Act No. 247/2020 Coll. or Act No. 185/2020 Coll). on certain measures to mitigate the impact of the SARS CoV-2 coronavirus epidemic on the tourism industry) has resulted in a significant loss of revenue for owners and operators of tourist attractions. It is therefore not surprising that admission prices have increased since operations resumed in 2021, which may be a reason for some visitors not to visit. Another factor affecting admission prices is the rising rate of inflation (the average annual inflation rate in 2023 was 10.7%, Czech Statistical Office, 2024).

For the reasons mentioned above, the questionnaire included questions about visitors' financial considerations. The opening question of this section was directed at the amount per person that visitors spend when visiting a tourist attraction (see Figure 5). In order disproportionate amounts, categories for economically weaker visitors up to CZK 250 and economically stronger customers above CZK 750 have been purposefully created. Most respondents stated that their financial limits were CZK 250 per person (24.9%) and CZK 500 per person (37.4%). Most of the time, these are families with children, and any expense for more than one person is financially burdensome. Visitors who do not have other family members or are travelling with only a partner are willing to pay admission fees above CZK 750 per person (17.7%).
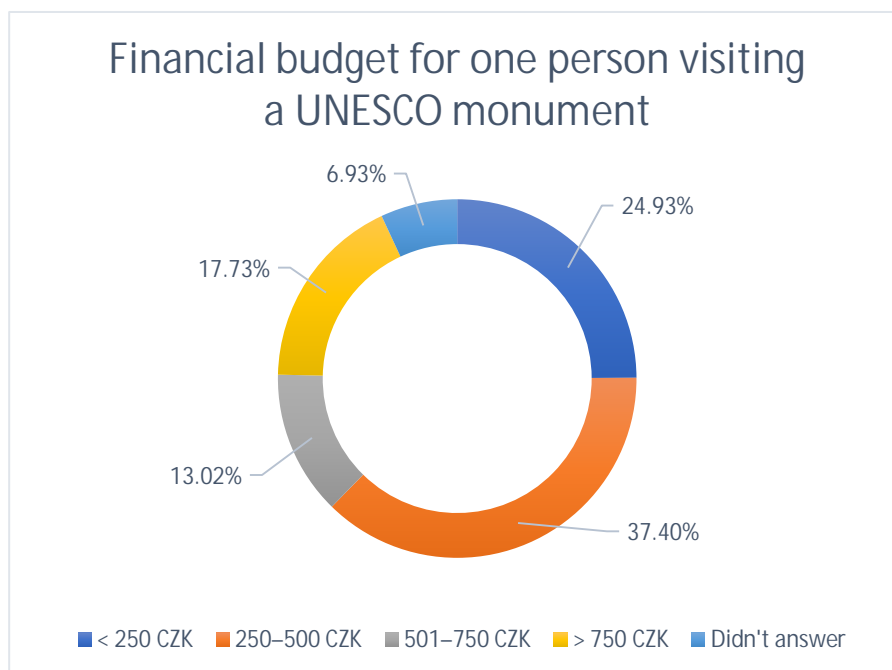
Figure 5. Financial budget for one person visiting a UNESCO site

In order to differentiate the amount of the admission prices also according to the personal preferences of the visitors, we asked them about the maximum amount they are willing to pay for the admission to an attraction. We differentiated price levels by category into adult, discounted admission (student, senior and disabled) and family admission. In the category of single adult admission, there was a high variance of values (ranging from CZK 2 to CZK 1,200). The low value of CZK 2 cannot be considered entirely plausible. Most respondents reported a financial limit of CZK 250 (15.5%), followed by CZK 200 (14.6%) and CZK 300 (13.2%). The values of CZK 150 (9.4%), CZK 500 (9.1%) and CZK 100 (7.9%) were also recorded frequently. Logically, the discounted admission was recorded at a lower value than the full adult admission. Even 1.8% of respondents opted for zero value, i.e. free entry. The highest values recorded were CZK 500 (1.2%) and CZK 400 (0.9%). The most frequent values in the set were recorded for discounted admission of CZK 100 (21.1%) and CZK 150 (14.9%). The last category observed was family admission (2 adults + 2 children). Logically, higher amounts can be expected here, therefore the values obtained also range from CZK 0 to 2,500. However, in contrast to the highest amount received (CZK 2,500 CZK – 1 respondent), 3 respondents reported a zero value. In terms of frequency of value, the most frequently mentioned price level was CZK 500 (14.9%), followed by CZK 400 (9.9%) and CZK 1,000 (8.5%). Rounded amounts (CZK 200, CZK 300, CZK 600, or CZK 800) were mentioned more often. As many as 7.0% of respondents mentioned a total of CZK 2,000.

4. Discussion

The results presented in the paper showed that, despite certain constraints, visitors are willing to travel and visit tourist attractions. Most of the respondents visit UNESCO sites because they like history, architecture, and monuments. They travel alone or with their partner or family. A common mode of transport to a monument is their own car or caravan, but public transport (bus, train) is no exception. Public transport is used more often to get to the site, especially in historical towns. The more remote location of the site gives more reason to use a private means of transportation (car, bicycle). If visitors travel by caravan, they often have very limited parking options, especially in the historic town centres (Český Krumlov and Kutná Hora). The solution is to build Park & Ride, i.e. car parks in suburbs, and add infrastructure (toilets, dirty water sinks, drinking water sources, and electricity supply to the caravan). Such car parks can now be found, for example, in in Telč or Třebíč. A more detailed assessment of the services provided will be the subject of further research in this area.

The average admission fee to a UNESCO site, which is deemed acceptable by visitors, is CZK 325 (for adults), while in the event of discounted admission, it is CZK 144. Some monuments also offer a family admission category, with the average price being CZK 590. The researchers included an open-ended question at the end of the questionnaire: *What three other sites in the Czech Republic do you think deserve to be added to the UNESCO list, and why?* Respondents could answer anything because the question was open-ended. However, as it turned out, most respondents struggled with this question. They were unable to name a specific site that deserved UNESCO protection (45.6% did not respond). At the same time, 16.1% of respondents had no idea or chose the option I don't know. Some responses were

extremely broad (cities, all monuments, more natural historical sites, abandoned settlements, a collection of Baroque fountains, etc.).

The respondents proposed as new UNESCO sites not only cultural monuments (e.g. castles and chateaux like Karlštejn Castle, Bouzov Castle, Pernštejn Castle, Hluboká nad Vltavou Castle, Konopiště Castle, Nové Hrady Castle near Litomyšl) or natural monuments (e.g. Moravian Karst, Adršpašsko-Teplické Rocks, Jeseníky Protected Landscape Area, SOS Reserve, or Křivoklátsko Region), but also some technical monuments (e.g. the Industrial Complexes at Ostrava - Lower Vítkovice Area, Dlouhé stráně Power Plant, Hradec Králové Football Stadium, Velké Losiny Paper Mill, Terezín and Josefov Forts, Jindřichův Hradec Local Railways - narrow gauge railway, Pilsen Brewery or Bechyně Railway Bridge). The most frequently mentioned historical towns were Hradec Králové (7 times), Cheb (7 times), Tábor (4 times), Slavonice (3 times), Liberec (3 times) or Štramberk (3 times).

The results of the questionnaire survey indicated some gaps that the authors of the research will have to deal with in the future. This is primarily a one-sided focus on the Czech visitor. The questionnaire was distributed only in the Czech language, making it difficult to understand for many foreign visitors. In the next tourist season, the solution is to make the questionnaire available in English. This measure would also guarantee the feedback of foreign tourists, who constitute more than 70% of all visitors to Český Krumlov and Prague. Another limitation is the owners' and operators' unwillingness to tolerate the questionnaires' placement on their sites, as well as the respondents' willingness to complete the questionnaire, both of which are beyond the researchers' control. We can only offer to distribute the questionnaires through all possible information channels, but completion depends on the willingness of individual respondents. We also encountered a barrier when the site operators claimed that the physical collection box was an eyesore and unsuitable for the interior of a historic site.

5. Conclusions

The questionnaire survey served as the initial stage of a comprehensive research project that will continue throughout the subsequent years. The intention is to create a comprehensive view of the UNESCO sites in the Czech Republic from the visitor's perspective. The outcomes obtained will undergo a thorough examination, and the authors will employ statistical techniques to identify variables and their interdependencies. A comprehensive research report will be prepared and provided to the operators of the sites and the representatives of the voluntary association UNESCO Czech Heritage. In order to effectively plan activities during the following tourist seasons, it is necessary to respond more effectively to emergency situations. Such situations, such as the SARS COV-2 pandemic, can have devastating consequences for owners and operators of UNESCO sites in the Czech Republic. As elsewhere in the world, many Czech UNESCO sites depend on foreign visitors (e.g. Prague, Český Krumlov). Owners and operators should therefore be prepared for such situations and have a contingency plan in place. The authors aim to propose feasible measures and recommendations in the form of a handbook titled "Crisis Preparedness of

UNESCO Sites", aimed at site operators and their accompanying services, destination management, and the decision-making realm.

Conflict of interest: none.

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Is Agriculture 4.0 in Czech Republic More Real than Industry 4.0? Analysis of Selected Macroeconomic Indicators

Peter MARINIČ

Mendel University in Brno, Brno, Czech Republic; peter.marinic@mendelu.cz

Abstract: In recent years, there has been a lot of talk about the introduction of new technologies into the production process due to Industry 4.0 initiative, and in agriculture, Agriculture 4.0. Based on the analysis of data from Eurostat, it appears that the importance of the agricultural sector in the Czech economy has been decreasing since the 1990s, its performance and productivity are not adequate compared to other sectors. However, according to the available data, the agricultural sector can be characterized as an area of the economy in which the Agriculture 4.0 initiative has been manifested itself in recent years, especially in terms of evaluating the year-on-year growth of the relevant components of fixed assets. Even if the manifestations of this initiative are not reflected in the overall state of the sector assessed through labor productivity or the hours worked per person, the dynamics of the use of new technologies has been more pronounced in agriculture in recent years than in the rest of the Czech economy. It can therefore be concluded that the Agriculture 4.0 initiative in the Czech Republic has its impacts with positive prospects for the future.

Keywords: Industry 4.0; Agriculture 4.0; macroeconomic analysis; labor productivity; total assets analysis

JEL Classification: Q16; E24; O13

1. Introduction

Human activity is constantly accompanied by the effort to achieve better results. At the same time, we seem to be naturally wired to want more, to satisfy our needs to a greater extent, and our needs are inherently unlimited. Since we have only limited resources available to satisfy our needs, both in terms of obtaining them from the position of consumers, and in terms of their production from the position of producers, we are forced to manage the production process. It can be manifested in many ways, one of which is deciding what kind of consumption we choose to consume, as consumers, or what goods we choose to produce, as producers. Either way, it's essentially a question of resource efficiency and a question of productivity. These motives force us, as human beings in the role of consumers and producers, to think economically about the connections between our consumption and production. Thus, we are trying to increase the efficiency and productivity of our efforts to obtain more resources to meet our needs.

When such considerations lead to innovations in the production process, which can subsequently be identified as a turning point, then we can talk about revolutionary changes.

If such changes concern the industrial way of production, then we can label them as industrial revolutions, and if they concern significant changes in the approach to production in agriculture, then as agricultural revolutions. In history, humanity has already gone through several such changes, which have had an impact on the way we approach production and consumption itself.

The first such radical change in the way of industrial production, today referred to as Industry 1.0, was the introduction of the steam engine and its use in production. After the expansion of this approach to industrial production, there was a radical change in labor productivity, which led to an increase in the volume of production. Of course, such a change required sufficient capital investment made by producers, and at the initial moment led to the replacement of human labor by mechanization. However, its positive effects subsequently enabled an increase in production and consumption, and leaded to increase in employment.

The second identified turning point was the introduction of scientific management and the industrial method of production. It stimulated the emergence of mass production, factory lines and further increased labor productivity and the efficiency of the production process. Together with this approach, the approach of unification and standardization was introduced into production. This change was labeled as Industry 2.0.

The use of other innovations in the production process is associated with the third wave of industrial revolutions, which is characterized using electricity, computer technology and automatization of the production process. We call it Industry 3.0 (Gashenko et al., 2020; Lazanyi & Lambovska, 2020).

What those industrial revolutions have in common is that they have been retrospectively identified as turning points in the production process, with long-term effects on society and production process. The following waves of industrial revolutions are connected by the fact that they are already consciously induced by man, with the aim of intensifying and deepening radical changes in the production process, leading to an increase in productivity and production efficiency. The impact is then supposed to be in an increase in the quantity of goods produced and a reduction in the price of the given production, making the given production more affordable for consumption and at the same time more competitive on the market.

In this sense, we are talking about the Industry 4.0 initiative, which is based on a cyber-physical combination of production means, the use of advanced communication technologies, the Internet, augmented and virtual reality, artificial intelligence, remote control and interconnection of information systems, and other modern technologies. However, the significant emphasis on the technological side, which is contained in the Industry 4.0 initiative, can be perceived as a significant threat to the human position as part of the production process. This is also the biggest criticism of the Industry 4.0 initiative, namely that man as an employee will become unnecessary and will be replaced by machines in the production process. Even if these concerns turn out to be odd, the reactions have manifested themselves in the form of the Industry 5.0 initiative, which emphasizes the position and cooperation of humans in the future organization of production processes (Beke et al., 2020; Brahma et al., 2021; Flores et al., 2019; Grenčíková et al., 2021).

In the field of agricultural production, of course, the mentioned tendencies are also manifested, especially if we look at agricultural production as a part of industrial production. However, here we can also trace specific moments beyond the above-described influences aimed at increasing the productivity and efficiency of agricultural production. Among these influences we could include the discovery of new crops that is associated with the discovery of the world, approaches to increase yields from cultivated agricultural land, such as two-field and three-field systems, or the use of fertilizers and pesticides in agricultural production.

Currently, agricultural production is similar to the Industry 4.0 initiative, which is referred to as Agriculture 4.0. This initiative is associated with intensive use of new technologies in agricultural production. Even in the Czech Republic we can encounter the use of livestock sensors, automatic milking technology, automatic feeding technology, automatic faces handling systems, air conditioning units for pig and poultry farming, autonomous tractors and harvesting equipment, use of drones and satellite data, or soil sensors and capacitive sensors and many other new technologies use in agriculture production process (Marinič, 2023).

The previous analyses (Marinič & Pecina, 2021; Marinič, 2022) indicated that in the Czech Republic Industry 4.0 is rather a gradual process of evolutionary change of the production process than a radical change in the approach to industrial production. Thus, that the Industry 4.0 is rather evolutionary change than rapid revolution in production process. It is based on analysis of chosen economic indicators of the whole Czech economy. Of course, even in the Czech economy there are innovative producers who use available new technologies, however, their share in the total number of economic entities will obviously not be significant, since the impact of the introduction of the Industry 4.0 initiative is not reflected in significant changes in the overall data. On the other hand, if we wanted to identify a sector in which more significant changes may occur as a result of the implementation of the Industry 4.0 initiative, it would be the agricultural sector (Marinič, 2022).

In the context of the expected impacts of the Industry 4.0 initiative, there should be a sharp increase in labor productivity, measured as a share of output per employee, in companies that will use new technologies, as these producers will use non-negligible technological equipment that will contribute to increasing the volume of production, while reducing number of employees, or at least while maintaining their level. At the same time, this should be reflected in the volume of growth of fixed assets, and thus also in the increase in cost of fixed capital.

The goal of the paper is to analyze selected macroeconomic data that could be an indicator of the impact of the Industry 4.0 initiative in the Czech economy. Since the contribution is focused on the agricultural sector, attention is paid to comparing this sector with industry and the service sector, as well as with the data for the entire Czech economy.

2. Methodology

The aim of the contribution is to identify the impacts of the Industry 4.0 initiative with a focus on the agricultural sector, i.e. to identify the impacts of the Agriculture 4.0 initiative, because previous analysis (Marinič, 2022) indicated a potential impact in this sector.

The analysis is based on publicly available data through the Eurostat database, specifically using data sets under the code designation:

- nama_10_nfa_st (gross fixed capital formation);
- nama_10_a64 (the amount of production and selected economic indicators);
- nama_10_a64_e (the number of employed persons and hours worked).

The individual indicators were based on values using the national currency, i.e. the Czech crown, so that it was not necessary to consider the effect of changes in the exchange rate between the Czech crown and the euro. For the calculations of each year ratios, data in current prices were used, however, in the case of evaluating year-on-year changes, available valuation data in the prices of the previous year were used. This eliminates the effect of price changes, i.e. the effect of inflation for individual sectors. For the analysis, the longest available period was used, i.e. data from 1995 to 2022 were used. Due to the length of the assessed period, the potential impacts of the Industry 4.0 initiative, or Agriculture 4.0, should manifest itself in the data of recent years rather than within the entire period under review.

3. Results

Due to the length of the period under review, the data from Eurostat, assessing the overall development of the economy of the Czech Republic, can identify the expected development corresponding to changes in the structure of the Czech economy. Development of the selected indicators (Output, Gross Value-Added, Persons, Hours Worked for the whole Czech economy) are in the Figure 1. There are also presented shares of sectors of economy on the total value of the selected indicator for the whole Czech economy in per cent. The changes in structure of the Czech economy relate to the gradual reduction of the share of agriculture at the Output, similarly to the decrease in the share of industry and, conversely, the increasing share of services. It corresponds to the ongoing trends in changes in the economy, which is moving towards a significant strengthening of services in consumption. However, due to the historically traditional significant representation of industrial production in the Czech Republic, the representation of industry and services fluctuates around the value of 50% in relation to the Output in all NACE activities. The share of agriculture decreases from the original 4.2% to 2.4%.

However, a better understanding of the connection of individual sectors to the overall performance of the economy offers a view of the Gross Value-Added indicator, which better reflects the overall GDP of a given economy. Here we can already see the dominant position of the service sector with a growing share (from 56.6% to 65.3%) and corresponding decreases in the shares of industry (from 39.0% to 32.7%) and agriculture (4.4% to 2.1%). A similar change in the structure of the Czech economy is also reflected in the indicators of the number of employed persons and hours worked.

The information not presented in figures but worth mentioning is that the number of hours worked per employee for agriculture is the highest for all time. The indicator, assessed as a ratio of the number of hours worked per employee in relation to the total number of hours worked per employee in the entire Czech economy, is also growing during the analyzed
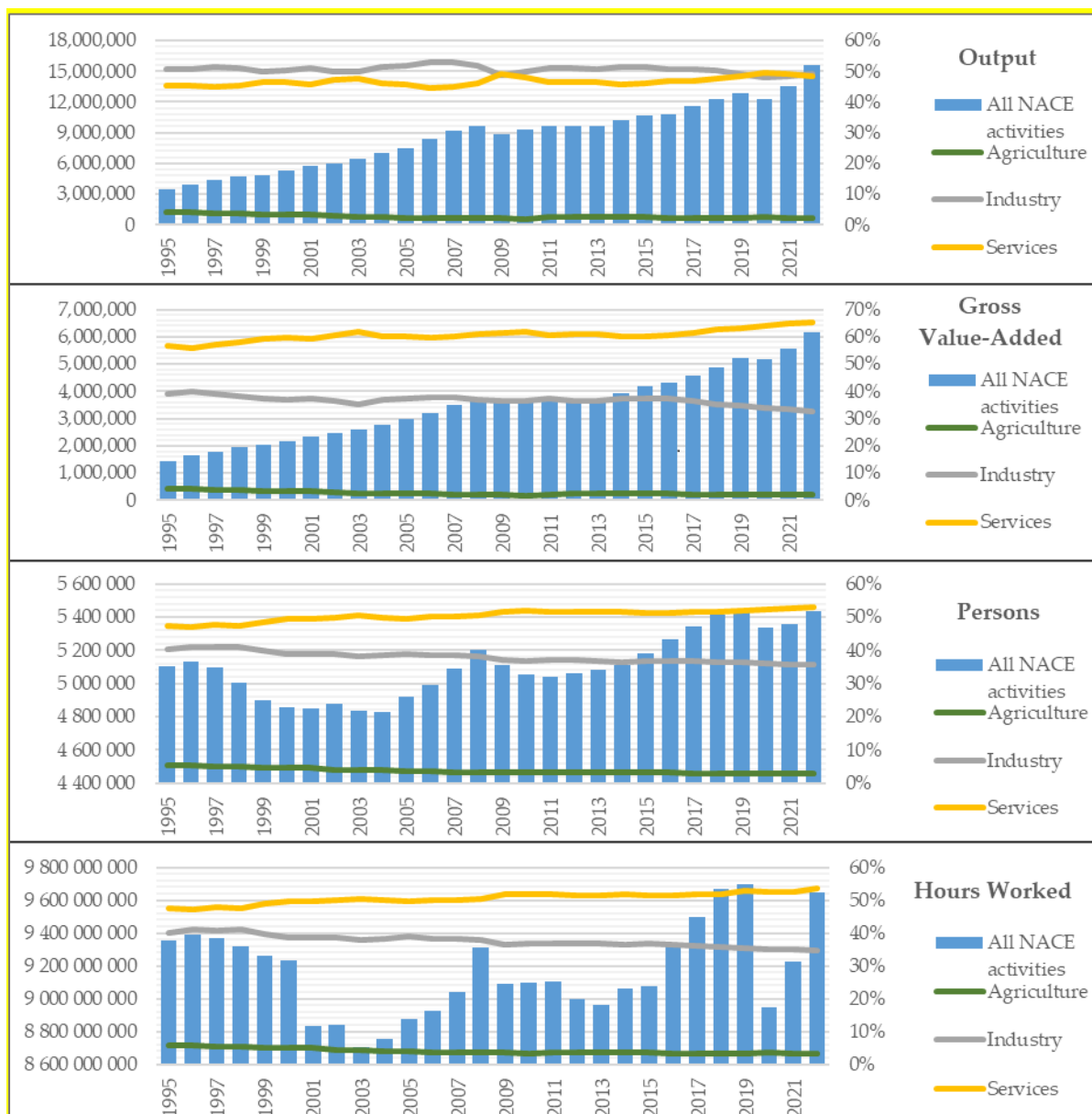
Figure 1. Development of selected indicators (column: absolute values at right axis in millions CZK for output & gross value-added and for persons & hours worked in thousands of units; curves: per cent share of sectors on All NACE activities values at left axis)

period. Therefore, if we were to assume that the implementation of the Agriculture 4.0 initiative will lead to a reduction in the work performance of employees in the given sector, the data does not confirm this assumption. This assumption is fulfilled predominantly in the industry sector, where the number of hours worked per employee is decreasing.

Also interesting, although not presented in figures, is the volume of employed persons, given the recalculated number of employees, which indicates that in the Czech economy, in all sectors, since 2005, there has been a tendency towards short-time employment. The available data regarding the division into persons employed and self-employed persons show that the share of sole-entrepreneurs in the Czech Republic is around 15% in the long term, however, in the agricultural sector this share is constantly increasing from 18.64% in 1995 and will reach 35.48% in 2022.

The labor productivity is another area that should be affected by Industry 4.0, i.e. Agriculture 4.0, initiative. It should increase with the introduction of new technologies to the production process. Labor productivity for individual sectors and for the entire Czech economy can be assessed from through Output per Person ratios, or through contributions to the creation of GPD, i.e. through the Gross Value-Added per Person ratio, both in current prices. In addition to the labor productivity per employee, it is also possible to assess labor productivity per hour worked, which may vary due to the different number of hours worked by employee in individual sectors. Figure 2 provide an analysis of these data.
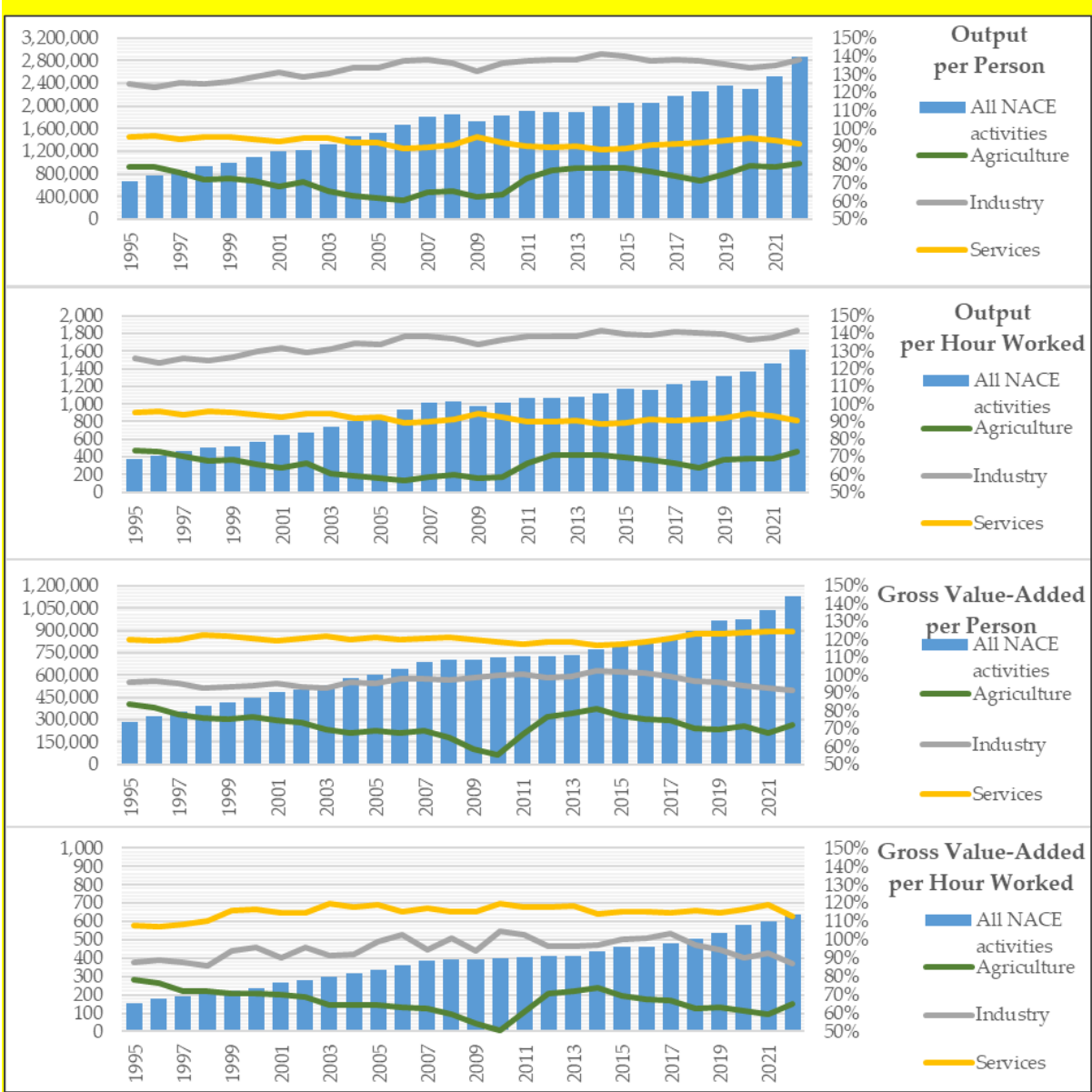
Figure 2. Development of selected indicators (column: absolute values at right axis in units of CZK for output & gross value-added per person and per hour worked; curves: per cent share of sectors on All NACE activities values at left axis)

Labor productivity calculated from Output and Gross Value-Added (Figure 2) in current prices is expected to increase throughout the monitored period, both per person and per hour, due to inflation and implementation of new technologies. It can also be seen that the industry

sector achieves higher values calculated from the Output, while the service sector achieves higher values when calculated from the Gross Value-Added. In both cases, the agricultural sector achieves below-average values compared to the entire Czech economy. According to the Figure 2, it can be seen, that in agriculture there is decreasing trend in productivity till 2010 with the significant increase in productivity in the years after 2010.

However, this analysis is distorted by the effect of year-on-year price changes, and therefore it is more appropriate to look at the year-on-year increase in productivity using values of chosen indicators in previous year prices, which takes price changes into account and reflects values of the real increase in the Output and Gross Value-Added. Such year-to-year changes of productivity according to selected indicators is presented in Figure 3.
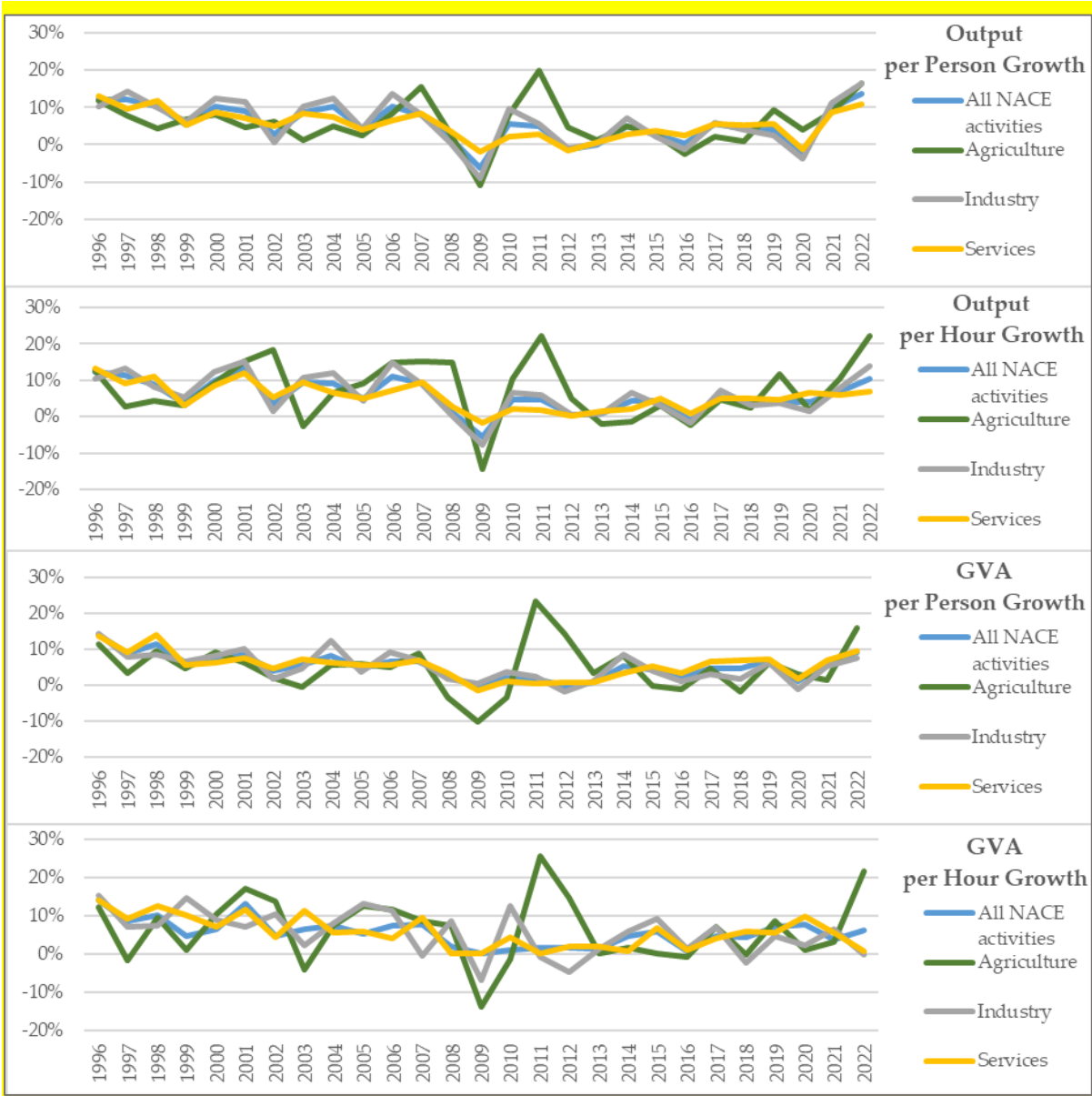
Figure 3. Development of year-to-year productivity per cent change based on previous year prices

As can be seen in Figure 3, changes in the real values of labor productivity fluctuate significantly from year to year. These oscillations are particularly pronounced for the agricultural sector and, moreover, for the Gross Value-Added. The growth of productivity

can be seen in current prices (Figure 2) and previous year prices (Figure 3) in all sectors, with the specifics in agriculture, where there was lag in the labor productivity progress till 2010 with a subsequent revival of labor productivity growth after 2010.

Another area in which the effects of the implementation of the Industry 4.0 initiative, i.e. Agriculture 4.0, should be manifested is the area of costs. Figure 4 provides an analysis of the development of Compensation on Employees and Consumption of Fixed Capital.
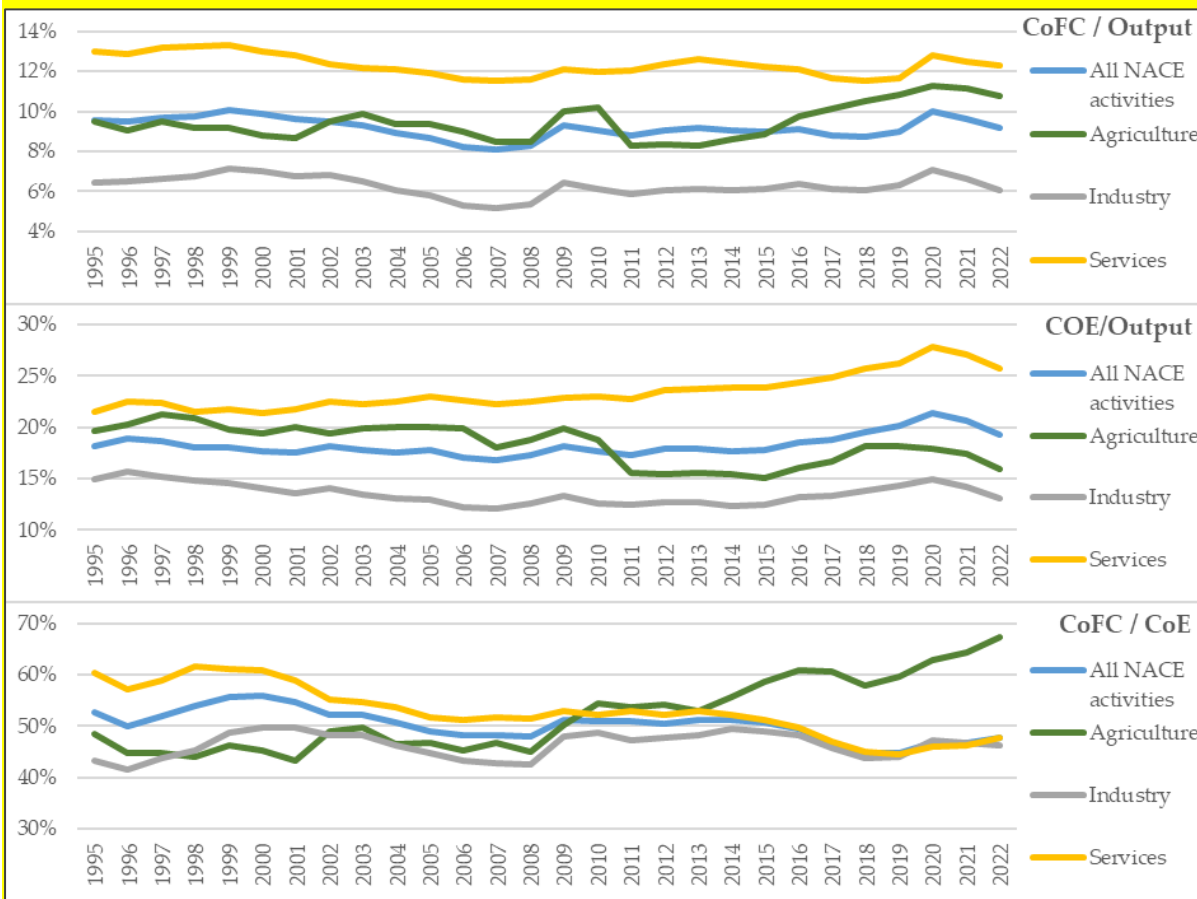
Figure 4. Development of ratios of compensation on employees and consumption of fixed capital to output and their mutual ratio.

Compensation on Employees should increase in total value because of increasing wages of employees, which may increase due to higher labor productivity. Consumption of Fixed Capital should also grow, as there should be a renewal of investments and especially investments in new technologies. Even though both indicators should increase in absolute terms, the effect on the change in their share in the volume of total production may not be so clear-cut, precisely because of the effect of the change in labor productivity and the efficiency of the use of technology in the production process. However, if there were to be replacement of human labor with technological equipment, it should be reflected in the mutual ratio of both indicators.

As can be seen in Figure 4, the mentioned trend of the increase in the costs indicators are manifested in absolute values for the entire analyzed period in all sectors. In the industry and services, this increase in absolute values is also continuous even when looking at year-on-year changes. In the case of industry, it reaches values of 3.84 in the case of Compensation on

Employees and 4.11 in the case of Consumption of Fixed Capital, which indicates a slight increase in the investment intensity of industry. In the case of services, the increase in the value of Compensation on Employees reaches 5.73 and in the case of Consumption of Fixed Capital 4.54, which in turn indicates an increase in the intensity of workforce. In the case of the agricultural sector, there is also an increase over the entire monitored period, namely in the case of Compensation on Employees in the range of 2.06 and Consumption of Fixed Capital in the range of 2.86, which indicates a growth in investment intensity, but the year-on-year development of the absolute value of the indicators is uneven. A more significant increase in values can be identified from 2013, in the case of Compensation on Employees from 2016 respectively.

Compensation on Employees is higher than Consumption of Fixed Capital in all sectors, which is also reflected in the higher ratio of this indicator to Output in Figure 4. In the industry, the development of both ratio indicators can be assessed as balanced. In the case of the services, there is the increasing share of Compensation on Employees on Output compared to the slightly decreasing share of Consumption of Fixed Capital on Output.

The development in the case of the agricultural sector is rather specific, with oscillations until 2011 in both indicators, but in the following period there is an increase in the share of Consumption of Fixed Capital on Output, while at the same time the value of the share of Compensation on Employees on Output is lower. This is also reflected in the sharp increase in the mutual ratio of these two indicators, which indicates the increasing importance of fixed capital costs compared to personnel costs. It can therefore be assumed that in the agricultural sector there are investments in Fixed Assets, among which there are also investments in new technologies.

It is clear from the data in Figure 5, there is an increase in the Total Fixed Assets over the entire monitored period, both in its net concept and in its gross concept. Also identifiable is the period of the 1990s, when investment activity is higher, followed by a period of lower growth, which has increased again in recent years. Increases in ICT Equipment and Intellectual Property items for the entire Czech economy and at the same time for the industry and service are around 10%. Overall, a slight increase in the share of these components in the total value of Total Fixed Assets can also be seen in the entire Czech economy and at the same time in the industry and services. These data would therefore indicate that in the Czech economy there are investments in new technologies that can be connected with the Industry 4.0 initiative, especially with regard to the growth of the share of these components in the industry since 2011. On the other hand, there is no identifiable sharp year-on-year increase in those indicators during analyzed period that would indicate that this is a significant change in production processes neither in the industry nor in the service.

The agricultural sector appears to be specific again, while investments in ICT Equipment and Intellectual Property in agriculture decreased by 2010, which also resulted in a decrease in the share of these components in Total Fixed Assets. Since 2010, a significant growth of investments in this area can be seen. Although the share of ICT Equipment and Intellectual Property on Total Fixed Assets in Agriculture is still the lowest among all sectors, the dynamics of change have been more pronounced in recent years.
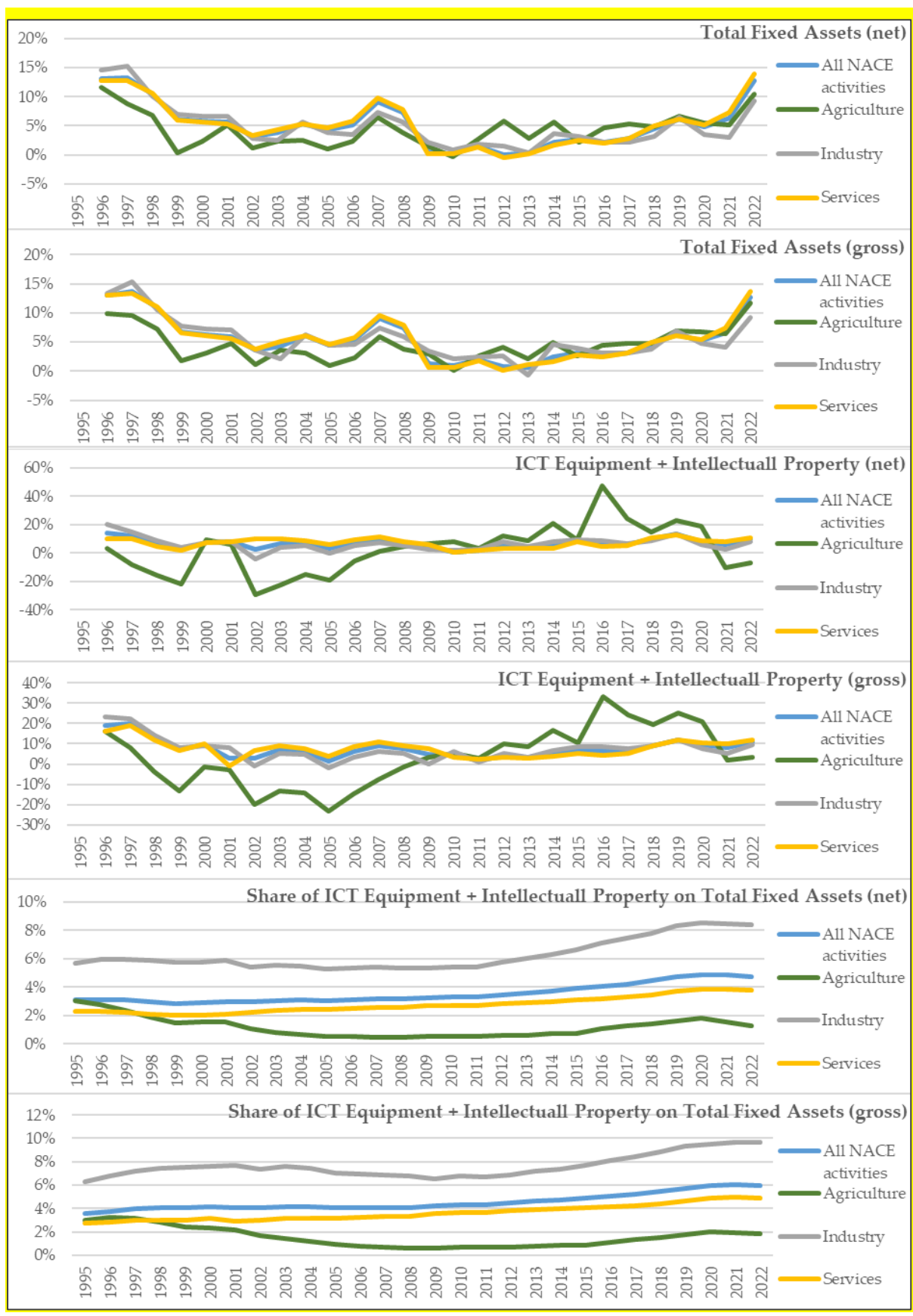
Figure 5. Development of year-to-year change of total fixed assets and selected component of fixed assets; development of ratio of selected components of fixed assets on total fixed assets

4. Discussion

The results of the analysis correspond with other studies that identified the impact of Industry 4.0 on the economy, especially in labor productivity (Kurt, 2019; Trenovski et al., 2020; Grenčíková et al., 2020). These analyses indicate that as a result of the implementation of the Industry 4.0 initiative, there is an increase in labor productivity and an increase in the production capacity of the economy, reflected in GDP growth. The results also correspond to previous analyses, which indicated that the more significant impacts of the Industry 4.0 Initiative should be manifested in the agriculture (Marinič, 2022).

5. Conclusions

The results of the analysis of selected economic indicators available from the Eurostat database indicate that in the conditions of the Czech economy in connection with the Industry 4.0 initiative, i.e. Agriculture 4.0, there are no radical changes in the production process. These findings therefore correspond with the previous analyses (Marinič & Pecina, 2021; Marinič, 2022) carried out. Even the current analysis indicates that the Czech economy is rather an evolutionary development, which is manifested in the increase of the production possibilities of the Czech economy, both from the point of view of the Output and from the point of view of the Gross Value-Added, through the evaluation of the given indicators in current prices even when valuing production at previous year prices. At the same time, there is a slight reduction in the number of hours worked per person. There are also investments in Total Fixed Assets with an increasing share of ICT equipment and Intellectual Property on Total Fixed Assets.

Considering that the previous analysis (Marinič, 2022) indicated the possibility of identifying the impacts of the implementation of the mentioned initiatives in the agriculture, the current analysis focused on that sector. The analysis shows that the agriculture in the Czech economy shows specifics in relation to the industry and services. It can be assumed that these specifics relate mainly to the transformation of the economy in the 1990s and the gradual decline in the importance of the agriculture from the point of view of the overall economy. On the other hand, the analysis suggests that the implementation of the impacts of the Industry 4.0 initiative, or Agriculture 4.0, really manifests itself in agriculture rather than in the industry or services.

Even though the agriculture lags the industry and services in many respects, from the point of view of the implementation of Industry 4.0, or Agriculture 4.0, it seems to be more successful than the other two sectors, especially according to the dynamics of increase of analyzed components of Fixed Assets since 2011, that can be assigned with the Agriculture 4.0, which create optimistic expectations for the future of agriculture in Czech Republic.

Conflict of interest: none.

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Differences Between Management Teaching at Universities and the Used Practice

Lucie MAŘANOVÁ

Prague University of Economics and Business, Prague, Czechia; lucie.maranova@vse.cz

Abstract: This study investigates the differences between what is taught at business universities and what is used in practice by SME managers and owners. The research involved 11 semi-structured interviews with teachers of general management courses, specialist management courses, SME managers and SME owners in the Czech Republic. Based on their responses, a difference diagram was developed. The diagram derived from the study's findings visually represents the gap between academic teachings and practical applications, particularly emphasizing areas such as cost-cutting strategies and ethical management, where significant divergences occur. This visual representation not only clarifies the extent of these differences but also underscores the importance of bridging the gap through a more practice-oriented curriculum in business education. The answers show that there are big differences between the curriculum of general courses and management practice, but if we look at other specialized subjects like Operations Management or Project Management, the differences become significantly smaller. Thus, if a student takes a comprehensive management education, and not just the basic general courses, the student should have a sufficient knowledge base to function successfully in practice.

1. Introduction

Business schools are institutions that aim to provide education to students seeking to enter the business world. The content of business school curriculums is designed to equip students with theoretical knowledge and practical skills that can be applied in real-life business settings. However, several scholars have raised concerns about the effectiveness of business school education in preparing students for the challenges of the business world.

Many books have been written about the poor teaching of management in schools, such as "Shut Down the Business School: What's Wrong with Management Education" by Parker (2018), "Nothing Succeeds Like Failure: the Sad History of American Business Schools" by Conn (2019), and "The Golden Passport Harvard Business School, the Limits of Capitalism, and the Moral Failure of the MBA Elite" by McDonald (2018). It could be perceived that education (not just management education) is in bad shape from the reactions to articles in the mainstream media, where comments like "What good is this school going to do them?", "Another graduate to work in a Maccas." arise (Šára, 2023; ČTK, 2023).

This study has focused on finding the key differences between what is taught in management classes and how managers act in practice. It is used to understand whether the teaching is out of touch with reality or in line with it, and whether as a whole it is fulfilling its function of preparing the student for their future profession.

2. Theoretical Part

Harrison et al. (2007) acknowledge that the pressure on colleges teaching business to make their curriculum both vocational and relevant is overwhelming. However, they see academia as having a huge advantage over, for example, management institutes and consultancy centers. According to the authors, the advantage of universities is their multi-disciplinarity, and the aim of universities should not be to adapt 100% to the real environment but to educate versatile students who have good critical thinking skills and are familiar with paradigms so that they can make good decisions in their management practice. This is why they call for more collaboration between business universities and other disciplines such as philosophy, art, and sociology. Shoemaker (2008) argues that business schools need to stop focusing on narrow technical skills and instead focus on interdisciplinarity and critical thinking, ethical leadership, and social and environmental responsibility. He calls for a more holistic approach to management education that incorporates insights from disciplines such as psychology, sociology, philosophy, and sustainability and prepares graduates to address pressing global issues such as climate change and inequality.

Also speaking positively for universities is the research of Paton et al. (2014) who ask what relevance even means. They warn against sudden changes in approach and teaching just to make everything momentarily relevant. The way forward, the authors argue, is to stay with scientific theories and blend them with the world of practice. The authors tested and analyzed their approach using the principle of a long-term partnership between a UK university and a multinational corporation. They also introduced the notion of "relevate", which means that from seemingly useless rigorous theories that are not useful for a normal life, we create relevant experiences by linking them to practice and showing them in real life (Paton et al., 2014).

Recommendations for business schools to follow to minimize scientific rigor and increase relevance were put together in a model. This model is based on management being taught by so-called executive professors, i.e. people from the field. Even working with managers has its pitfalls; in their model, for example, they caution against not having an executive professor actually teach courses that they understand and that meet expertise; furthermore, someone must be dedicated to these executive professors to teach them, help them with syllabus development, or see that they fulfill all administrative duties (Clinebell & Clinebell, 2008).

In contrast, Antonacopoulou (2010) sees the way forward in a more critical approach. The author focuses on a reflexive critique based on the so-called phronesis, a type of practical wisdom that emphasizes ethical and political aspects. The article suggests that such an approach can help business schools develop a more nuanced understanding of business and society and can lead to a greater impact on the world. Phronesis can help with ethical decision-making, leadership, innovation, social responsibility, and strategic thinking. Thus, Antonacopoulou puts a more global worldview and an emphasis on ethics and geopolitics in

the classroom, which will then help students in the real world. Ma et al. (2020) also agree with a greater approach to critical thinking and ethics.

These studies show that concerns about the relevance of teaching in business-oriented universities persist and are, according to some authors, justified. At the same time, however, there are two streams of thought, some such as Antonacopoulou (2010) and Ma et. al. (2020) see the path more in critical thinking and ethics, while Clinebell and Clinebell (2008) and Paton et al. (2014) aim at involving practitioners in teaching and linking theories to practical examples, approaches that are of course not mutually exclusive.

But is this the reality? How big is the gap between teaching in schools and the work that graduates encounter? That education can never be completely relevant to the environment is understandable, programs have to be approved and what was valid at the beginning of the studies may not be a complete reality at the end of it, thanks to technological innovations our world is rushing forward ever faster.

This research has focused on identifying specific factors where management teaching and management practice diverge. The purpose of this study is to describe the key differences between the curriculum delivered by management teachers and the priorities perceived by managers. The study answers the research question: What are the key differences between what is taught about management at universities and what practitioners in the field use in practice?

3. Methodology

Based on the literature search and previous research, a form of qualitative research using semi-structured interviews was chosen to help identify key differences between what management teachers at universities teach and perceive as important to convey to students, and conversely what top managers and business owners use and perceive as priorities in practice. Qualitative interviews were judged appropriate in this case because the content of the research is not intimate that the interviewee might be reluctant to answer; instead, the aim is to obtain facts, reasons, and causes for certain practices (Kvale, 2008).

First, an interview guide was developed following the methodology described in Arsel (2017). This guide included the research question, interview objective, sample, topics, and outline of the questions. The interview was semi-structured, so the questions were mainly used to discover themes and to ensure that themes weren't missed during the interview. While non-scripted questions surfaced according to the respondent's answers. Due to the nature of the research and the two groups that the research compared, two versions of the guide were also created - one for managers and one for teachers. The interview first included warm-up questions, for the teachers, e.g. what subjects they teach, what they enjoy most about a particular subject; for the managers and owners, it was a question about their experience and the company where they work. This was followed by questions used to identify key differences between what teachers consider important and teach, and what is important to managers and business owners. In the end, participants were given the opportunity to revisit any topic or share anything else they felt was important that I had not covered in the interview.

The context of the research is also important because much of the research on the relevance of teaching or differences in teaching and practice is from the UK or the US, where the education system is diametrically different opposed to, for example, the Czech Republic or Germany, so experiences and practices may differ. It is therefore important to say that these are differences in teaching viewed in the Czech Republic and all respondents were from the Czech/Slovak origin and living in the Czech Republic (Wilson, 2008).

A pilot interview was conducted in December 2022 to check that the questions were understandable and, above all, relevant to the topic. Due to feedback from the interview, the questions were modified and further expanded to include several additional topics. Then, in January 2023, 4 interviews were conducted with management teachers from the Department of Management at the University of Economics in Prague, and in February 2023 interviews were conducted with 4 top managers /business owners, these were SMEs. Based on the results of the interviews, 3 additional interviews were conducted in February 2023 with teachers of Operations and Project Management from the Department of Management at the Prague University of Economics and Business and Jan Evangelista Purkyně University in Ústí nad Labem. Table 1 describes the sample size in more detail and the professional focus of the respondents as well as their codes; 11 interviews were conducted in total. The interviews lasted on average of 45 minutes. Three interviews were conducted online via the MS Teams platform due to the time constraints of the respondents, where it was more convenient for them to be interviewed in the evening from home.

Table 1. Sample Size

Academics		
Number of respondents	Specialization / Focus	Code
3	General management (basics, principles)	T1, T2, T3
4	Specialized Management (Project and Operations Management)	T4, T5, T6,T7
Managers and owners		
Number of respondents	Specialization / Focus	Code
2	Owners of SME (e-grocery store; manufacturing company)	M1, M2
2	A top manager in SME (marketing agency; accounting)	M3, M4

Semi-structured interviews were recorded with the consent of the respondents, then manually transcribed and transferred to MAXQDA software where they were coded. The coding was done in the lean coding of Creswell (2012), where the 10 most important codes (e.g., negative attitude towards firing employees or cost is a company priority) emerged at the beginning, these codes were then expanded and concretized, and finally reduced to 6 categories (cost is a priority, ethics in cost reduction, technological innovation as a key to cost reduction, dealing with competitors, competitors as a friend, sharing know-how) containing more detailed sub-codes. Analysis of the codes and the content of the interviews led to the development of the diagram described in the following section.

As a complement, the syllabi of the subjects taught by the questioned respondents were also analyzed - namely Principles of Management, Management for Computer Scientists and Statisticians, Operations Management, Project Management, Management and Organization in Material Culture, and Management of Immovable and Movable Cultural Heritage. At the same

time, observations were made in 2 lectures and 2 seminars of Operations Management (15 February and 22 February 2023) to determine how practice is linked to theory, thus verifying the veracity of the interview answers. Finally, the PROJEKŤÁCI AND PROJEKŤAČKY Facebook group was also analyzed based on the interview responses in February 2023 to see if there is indeed an active pooling of project managers to share know-how.

4. Results

The differences between the thinking of teachers and managers/owners were already apparent after the first set of interviews. However, it turned out that there is a big difference in the subjects that a given teacher teaches. Therefore, three additional interviews were conducted with Project and Operations Management teachers. The general management courses include Principles of Management, Management for Computer Scientists and Statisticians, and Management and Organization in Material Culture. Other topics were also discussed in the interviews, but the different groups could not find a consensus on them, these topics are discussed at the end of this chapter.

4.1. Differences between General Management Teachers and SME Managers/Owners

The most significant differences can be found in Figure 1. Diagram of differences, which shows the greatest mismatch between the priorities of General Management teachers and SME managers/owners, with the addition of the Project Management teachers segment described in the next subsection. The data and statements in the model are those where all respondents had the same or similar opinions.

General Management Teachers	Disconnection	SME managers and owners
Cutting costs should not be a priority		Reducing costs is a priority
Reduction through technological innovation is the way to go		Technological innovation is costly and uncertain
Emphasis on ethics in management and leadership		I don't think so much about ethical issues
Meeting competitors can be stimulating		Meeting competitors can hurt me
Joining management clubs is stimulating		I'm in a club, but I'm not very active

Connection

Project Management Teachers
Fitting in the cost of a project is a priority
Technological innovation is important but expensive
The project must be ethical
Competition is another project stakeholder
PM clubs exist and are active

Figure 1. Diagram of differences

A very prominent issue for both general educators and SME managers and owners is costs. Teachers view cost reduction as a last resort, they see reducing staff, reducing product quality, or the quality of the production itself as very problematic, which can result in e.g. higher air pollution. Teachers' views are comprehensively represented by the following answer of respondent T1:

"It's always at the expense of something else, somebody gets a pay cut, somebody gets fired, even if the amount of work stays the same, so I think it's a wrong problematic practice."

Respondent T3 then highlighted the detrimental results of the constant pressure to cut costs in the effects it has on staff. According to them, an employee often has to cover the work of several people because the number of staff is being cut, only to be caught out by health problems such as a heart attack or burnout syndrome. On the contrary, technological innovation, in the form of a more modern production line, retraining of employees, and buying more durable materials (less scrap), seems to be a suitable alternative.

Managers and owners, however, struggle with costs in their daily practice, and their answers show that costs are indeed a priority and something they monitor regularly. Respondent M3, a manager working in services, described how he regularly monitors new systems and PC programs to make work easier for employees, i.e. reduce the cost of time, or watches the prices of these applications, always trying to get programs like Adobe Photoshop or Microsoft Office at a discount. Respondent M1, an owner of an e-grocery store, monitors costs every week because he is constantly communicating with both suppliers and distributors, and this whole logistics chain is trying to reduce costs and in turn, maximize its margins. It is a priority for him to know where he is cost-wise, where he needs to tighten up, and where he needs to cut back. For technological innovations, the participating managers and owners always imagined something big in the form of a new plant or a completely new product, acknowledging that it is something necessary. They have a neutral attitude towards it, and their answers showed a great deal of caution and even distrust towards technological innovations, as in the answer of M2:

"Do you know how much it would cost me to invest in a new line? It's tens of millions, no one knows if it will pay off before it gets up and running before people learn with it. We have an older line from Holland, it's proven, it has a higher failure rate, but everyone here knows what to do with it."

A second very strong theme that resonated through virtually all the general management teachers' responses was ethics, whether it was about cost or competition, teachers always emphasized that everything had to be within the bounds of ethical behavior. The inclination towards ethical issues in the Department of Management of the Prague University of Economics and Business is evidenced by an internal document on the expertise of individual teachers in the department, 5 out of 20 lecturers (25%) identified topics such as moral reasoning and decision-making, dishonesty and cheating, corruption, applied philosophy and ethics, business and managerial ethics, ethical challenges as their main priority and their specialization. Managers and owners see the topic as rather grey, the term ethics only came up in the interviews when they were directly asked about it, while teachers included it as an important pillar right in their initial answers. Managers and owners were aware that ethics and moral behavior were important, the boundaries of ethics in this case were different from those of teachers, for example, cutting costs through redundancies did not seem unethical to them, it was part of business in their view.

As far as competition is concerned, in the Principles of Management course teachers do not define themselves in relation to the competition and rather show students the tools they can use to compare themselves with the rivals. They have strong reservations about price wars and similar practices on the edge of the law. On the other hand, if they were to advise students to be in contact with competitors and to act in a friendly spirit, they certainly see this as a promising opportunity. Managers are very skeptical about communicating with competitors and negative emotions were evident from the responses, respondent M4 said:

"So of course, we are not mean to each other, but I can't imagine writing to Miloš over there from a rival agency: "Hey man, what are you doing tonight, let's go for a beer and talk about how business is going?" I don't think that's realistic, if I got a message like that, I'd think he was trying to get some important info out of me."

A final theme that resonated strongly between the two groups was that of networking and sharing know-how. The teachers interviewed see great potential in various associations such as the Chamber of Commerce, and various business and management clubs. Although the managers and owners were able to acknowledge that there is certainly potential, they admit that they do not have time for such meetings, or even are members of an association, but are very inactive, do not attend meetings, or participate only as passive actors. At the same time, there was a feeling of motivation to receive, i.e., to get their tips and know-how from others, rather than to share their experience, which in practice would lead to the dysfunctionality of such clubs.

4.2. Specifics of Project Management Teachers

The differences or inconsistencies described above are well brought together and reduced to the compromise in Project Management, which is much more practice-based. Students who choose Project Management at the Prague University of Economics and Business take 5 courses, one of which is a direct internship. The introduction from Project Management then includes working closely on a project with a company such as ČSOB (VŠE, 2018, 2023a and 2023b). Teachers themselves are aware of their differences in the academic field, as stated by respondent T4:

"I will probably give you completely different answers than other colleagues. Project management is mainly about working with people from practice because you are not alone on a project, but you communicate a lot with the project owner, with the sponsor, with the stakeholders."

Teaching project management is consistent with Clinebell and Clinebell's (2010) research, with project management teachers having only part-time positions at the school and being dedicated to their project management profession. In contrast, general management lecturers admitted that they do not have work experience in management positions in a corporate or SME environment.

The Project Management approach to the above differences is as follows. Project costs must be accurately calculated and then, once the project is approved and commissioned, they must be kept. Any changes must be justified and approved. Therefore, working with costs is important

and a normal part of a project manager's job, but there is not the pressure to cut costs that is described by general management teachers or felt by managers and SME owners from non-project backgrounds. Rather, it is about selecting the most appropriate project delivery method at a reasonable cost. The compromise position is perceived by the interviewees teaching Project Management also in technological innovation, for the projects themselves innovation is very important and must be taken into account. As for project management itself, innovation in the form of new and better software may be the answer. However, they acknowledge that technological innovation is very costly and unless it is the very purpose of the project, for example, to introduce a new production line, it may not fit into the project budget.

A very interesting position is maintained by Project Management teachers towards the competition. For them, they are "just" another stakeholder in the project who needs to be observed, and watched over and you should also maintain relationships with them. Price wars or similar practices are out of the question for Project Management teachers. Instead, they address price and associated costs in ROI, which is one of the leading metrics of project success when it comes to, for example, the mentioned installation of a new production line.

As for joining clubs and sharing know-how, like the general management teachers, the Project Management teachers recommend this practice and even give an example of a working practice. There is a group called PROJEKŤÁCI AND PROJEKŤAČKY on Meta's Facebook, which has over 1,800 members and brings together project managers, see Figure 2. The platform is used for questions, tips, and organizing meetings. In this way, it fulfills the objective of sharing know-how.

Figure 2. Screenshot from Facebook group PROJEŤÁCI A PROJEKTAČKY (own screenshot, Facebook, 2023)

4.3. Operations Management and Other Topics

A very specific subject is e.g., Operations Management, from the interview with 1 respondent teaching this subject, the analysis of the syllabus, and the observation of two lectures and two seminars on this subject, it is clear, that this subject behaves much more in line with the beliefs of owners and managers. For example, given that the course content is to impart the knowledge needed to determine production lot size or lead time to students; it

looks at these facts from a practical perspective. It was also evident from observations during a lecture that tips and cases from practice are included in the teaching, where much less emphasis is given to theory as to the actuality and reality of application.

The interviews conducted also sought to uncover other important themes, each respondent, whether manager or teacher, viewed them quite differently. The topic of donations and financial support was viewed as controversial, whether it was support for political parties, culture, or sponsorship. In this question, teachers and managers raised opinions such as T1:

"I think it is legitimate, but there is a question of degree. I think even organizations should understand that if they send 50 million to someone, it's probably not okay and they are gaining power over them, even though they might have meant well. For me it has room, it's a company thing, of course, it's their marketing and a bit of lobbying as well."

Or as T2:

"It's still specific to us in that I assume most companies are just daughters of foreign mothers. So that the manager is accountable to shareholders and to his superiors who are completely outside the region. He has no connection to that local community; he doesn't need it and he doesn't do it. I think it's the same in England, the factory is in a small town, the manager lives in London, or even worse the factory is in Bangladesh, and he doesn't know what's going on there. So, then you have to make it terribly complicated and non-local and think I've got a CSR and I'm going to make a corporate foundation and it becomes professionalized. Someone through the Foundation will do my applications... And then there is the non-profit sector, which is also professionalized and is non-local."

Other topics on which there is no consensus include lobbying and the manager's responsibility for the economic well-being of the Czech Republic.

4. Discussion

The results show that systematic differences between teaching and practice do exist, but it is important to distinguish between levels. At the level of general management, the differences are indeed large and irreconcilable, general management teaching focuses on paradigms, ethics, and critical thinking, which fulfills the relevant objectives of teaching according to Shoemaker (2008). Reflecting on their call for interdisciplinarity, the study recommends incorporating insights from various disciplines, including ethics, to prepare students for complex decision-making in business.

The divergence in ethical perspectives between academia and practice resonates with Antonacopoulou's (2010) emphasis on phronesis, or practical wisdom. The study highlights the need for business education to integrate ethical decision-making within the context of real-world business dilemmas. The differences are visible in the approach to ethics, costs, and competition, where teachers see a more normative to utilitarian approach (Rachels & Rachels, 2012); while managers and owners are more pragmatic and do not exclude choices such as firing employees.

In contrast, specific courses such as Project Management or Operations Management are close to the ideal according to Clinebell and Clinebell (2008) and Paton et al. (2014), where the "relevate" principle is used, theories are shown through practical examples, teachers are so-called executive professors, and internships and close collaboration with specific companies are also involved in the teaching.

5. Conclusion

This study has illuminated significant disparities between the theoretical management teachings at universities and their practical application in the business world, particularly within SMEs in the Czech Republic. The semi-structured interviews with educators and practitioners have revealed a complex landscape of divergent priorities, approaches, and understandings of management that led to the creation of a diagram of differences.

A critical divergence was observed in attitudes toward cost management, technological innovation, ethical management, and competition/networking. These differences are overcome in the form of specialized courses such as Project Management and Operations Management.

As can be seen from the theory and the results, to want to mix both approaches – a broad outlook, critical thinking, paradigms, and ethical sensibility on the one hand and collaboration with practitioners on the other - in one course would probably be impossible. It is essential to look at the management curriculum as a whole and to observe the overall composition of the program, and only then to evaluate it because taking only one subject out of context will never encompass the whole complexity of the management field.

It cannot be forgotten that the topic has another actor that was not included – the students themselves. It would be interesting to triangulate the research through interviews with students. How does teaching management affect them? What teachers think they are communicating may be received differently by students and they may see different meanings in it. Conversely, another possible research may be to look at students' views during their time at school and a few years after school when they become managers or start a business and see if their views have changed over that time and, more importantly, what the reasons were for that change.

This research, while providing valuable insights into the disparities between management education in universities and its practical application in SMEs, particularly in the Czech Republic, is subject to several limitations. These limitations should be taken into account when interpreting the findings and considering their implications. A larger and more diverse sample might have provided a broader perspective and could lead to more detailed conclusions. The qualitative nature of this study, primarily based on interviews, introduces an element of subjectivity in the data interpretation. Different researchers might derive varying interpretations from the same data, which could influence the overall conclusions of the study. Concentrating on the Czech Republic provides a detailed local context but also limits the applicability of the findings to other geographical regions with different economic, cultural, and educational environments. While these limitations do affect the scope and applicability of the study's findings, they also open avenues for future research.

Conflict of interest: none

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worth noting that different forms of participation carry different potential for citizen influence on decisions made.

One way to give citizens real and direct influence over at least part of the expenditures made by local government units is to implement various forms of participatory budgeting. It takes different forms around the world (Dias et al., 2019), but they all have one thing in common – citizens have a direct influence on decisions related to the directions of spending public funds. In Poland, among the forms of participatory budgeting, we can distinguish civic budgets, village funds and local initiatives. The first two are forms of participatory budgeting as defined above. Local initiative, on the other hand, is a form of participation in which residents directly realize tasks financed by the municipality.

The aim of this article is to characterize and compare these three forms of public participation and to analyze their use by Polish municipalities in 2020-2022. The authors attempt to answer the following research questions:

- RQ1: What is the share of municipalities using the analyzed forms of public participation?
- RQ2: Which of the analyzed forms of public participation is the most popular?
- RQ3: Does the type of municipality affect the choice of the form of public participation?

The article consists of an introduction, a review of the literature on the subject, a description of the research methodology, a presentation of the research results and conclusions.

2. Forms of Public Participation in Poland

As indicated earlier, there are three forms of public participation in Poland that allow residents to have a real impact on the directions of spending public funds. These are civic budgets, village funds and local initiatives. Each of these forms has a different legal basis and a different procedure for its implementation.

The civic budget (also referred to as the participatory budget) is regulated by the Act of 8 March 1990 on municipal self-government. According to this act, the civic budget is a form of public consultation in which residents decide each year on part of the municipality's expenditures. In the case of cities with county rights, the creation of a civic budget is obligatory, and its amount may not be less than 0.5% of the municipality's expenditures included in the last submitted report on the implementation of the budget. In other municipalities, the civic budget is optional.

The village fund is regulated by the Act of 21 February 2014 on the village fund. It is a form of participatory budgeting dedicated to rural areas. The decision to separate the village fund is made by the municipal council. The funds of the village fund are

worth mentioning that Rowe and Frewer (2005) narrowed the concept of public participation by separating it from public communication and public consultation. These three concepts were differentiated according to the nature and flow of information between exercise sponsors and participants constituting together in their approach the category of public engagement. The main argument here was the aforementioned tidal influence on the decisions of those in power – referred to as the effectiveness of participation practices.

Fung (2006), on the other hand, points out that public participation mechanisms differ in the types of participants, the mode of communication between participants, and the influence of participants on public policy or action. In his view, these three dimensions form a space ("democracy cube") in which any particular participation mechanism can be located. One combination identified by Fung is one in which the main decision-making actors are citizens who have open access to participate in the process, make decisions through deliberation or negotiation processes, and have direct authority over public decisions or resources. The aforementioned features are characteristic of participatory budgeting processes in the broadest sense. In Poland we can point at civic (participatory) budget, village fund and local initiative.

The purpose of this article is to present and analyze the scale of operation in Polish municipalities of selected forms of public participation in Poland that meet the indicated combination of characteristics. It should be stipulated that the analysis will be subjected only to formalized on the basis of the provisions of national law solutions that can be commonly used in Polish municipalities. The article poses five research questions.

RQ1 What differences and similarities characterize the three forms of public participation selected for analysis?

RQ2 What is the scale of use of each tool by municipal governments in Poland?

RQ3 Do municipal governments use several tools of public participation in parallel?

RQ4 Are there differences between different types of municipalities in the use of individual participation tools (taking into account the specifics of the village council fund)?

RQ5 What is the territorial variation in this use?

It is important to note that this article is the first, in the existing literature, attempt at a comparative analysis of the extent of use in municipalities of these solutions covering all municipal governments in Poland. This is made possible by using reporting data on municipalities' interaction with residents from 2020-2022 made available by the Central Statistical Office.

2. Methodology

The article uses an analysis of the literature on theoretical and practical forms of public participation, an analysis of legal rules regulating the functioning of public participation of residents in the activities of municipal governments in Poland, and an analysis of statistical data on the scale and forms of public participation.

The data used came from the Central Statistical Office's survey SG-01 "Municipality statistics: interaction with residents" made available in the CSO's Local Data Bank database, from reports on the implementation of municipal budgets made available in the CSO's Local Data Bank and databases of the Ministry of Finance.

The study covered all municipal governments in Poland for the period 2020-2022. 19 districts of the city of Warsaw were also included in the analysis due to their analogous way of functioning in the area of public participation to urban municipalities.

Due to the limited availability of financial data, a detailed analysis of the direction of spending under the various tools of public participation was not carried out.

The study analyzed:

- The scale of use of individual public participation tools in Polish municipalities.
- Their co-occurrence within individual municipalities.
- The diversity of their use by type of municipality (urban, rural, urban-rural).
- The territorial distribution of units using these tools.

3. Results

3.1. Literature and Regulations Analysis

Poland is one of the few countries in the world where there are legal regulations at the national level that normalize the possibility and ways of using public participation in the management of local government units (Dias, 2018).

In practice, Polish municipalities have at their disposal a wide range of tools for including residents in decision-making processes. According to the theoretical concepts of public participation cited earlier, municipalities can both use tools with little influence on the decisions of those in power (e.g., sharing information, meetings with residents, educational and informational activities) and tools with greater influence (part of public consultations); tools involving selected groups of citizens or individuals (e.g., representatives of residents appointed to advisory organizations) and a larger part or the whole community (e.g., participatory budgets). Importantly, these tools can also be characterized by varying degrees of deliberation and negotiation opportunities - from public hearings to local initiatives.

Poland's basic legal regulations are primarily concerned with enabling municipalities to implement consultation processes. The essence of consultation processes is to seek opinions from municipal residents who do not have expertise in a given area, but who have a certain opinion on the subject of the consultation due to their direct involvement in the matter. These consultations can take a variety of forms - from meetings with councilors, through surveys to participatory budget type processes. Regulations on the possibility of involving residents in the municipal management process are also included in other laws. They concern, among other things, the possibility of creating a village fund, as a specific form of participatory budgeting for small rural communities, and the possibility of implementing a local initiative as a form of joint implementation of a public task for the benefit of the local community.

The three forms mentioned – civic budget, village fund and local initiative – are significantly different from the others at the disposal of municipal authorities. First, all willing residents can participate in them. Secondly, their consequence is the (in principle obligatory) implementation of a selected project/activity relevant to the local community. Thirdly, they are based on processes of deliberation and negotiation between residents in which the final shape of the selected project depends on residents' preferences. Thus, as noted

in the introduction, the municipalities' use of these three forms of public participation will be the subject of further analysis.

Civic (participatory) budget

Regulations devoted to civic budgets were introduced in 2018 (Olejniczak & Bednarska-Olejniczak, 2021). They concern the basic principles of the operation of this form of direct democracy, and the competence for detailed solutions was left to municipal authorities. The establishment of a civic budget in a given municipality is not mandatory. It depends on the decision of the authorities of a given municipality. However, in the case of large municipalities (cities with county rights), the establishment of a civic budget is mandatory. In addition, the law sets a minimum level of funds in the civic budgets of such cities. Within the framework of the civic budget, residents decide annually by direct vote on a portion of the municipality's budget expenditures. In accordance with the Law, the tasks selected under the civic budget are included in the municipal budget resolution. Thus, the municipal council, in the course of drafting the budget resolution, may not remove or significantly change the selected tasks. The legislator provided for the possibility of dividing the funds of the civic budget into pools covering the whole municipality and its parts in the form of auxiliary units or groups of auxiliary units. It is left to the discretion of municipal authorities to determine the requirements to be met by the civic budget project, in particular: the formal requirements to be met by submitted projects; the required number of signatures of residents supporting the project; the rules for evaluating submitted projects as to their legality, technical feasibility, their compliance with formal requirements, and the procedure for appealing against a decision not to allow a project to be voted on; the rules for conducting voting, determining the results and making them public, taking into account that the voting rules must ensure equality and directness of voting.

Village fund

Municipalities located in rural areas can establish "sołectwo" as auxiliary units (equivalents of, for example, neighborhoods or districts in cities). They usually cover the area of one or more villages. Their establishment is within the competence of the municipal council, and their goals, tasks and powers are defined in the statute of the sołectwo. The main purpose of the functioning of auxiliary units is to provide residents with the opportunity to influence the activities of the municipal authorities and to involve residents, non-governmental institutions and other entities in local affairs (Bednarska-Olejniczak et al., 2020). The municipal authorities may, in order to better implement the tasks of the sołectwo, create a village fund. This is a separate pool of funds in the municipal budget, which can be allocated for the implementation of projects indicated and selected by the residents of the village. This requires the fulfillment of three conditions: the project proposal submitted by residents must be the municipality's own task, it must contribute to improving the living conditions of residents, and it must be in line with the municipality's development strategy. These project proposals usually concern, among other things, the retrofitting or renovation

of village community centers, the development of green spaces, the construction and modernization of municipal roads and sidewalks, or the modernization of lighting.

Local initiative

The local initiative is a form of cooperation between local government units and their residents. It is aimed at joint implementation of a public task with the residents for the benefit of the local community (Gawłowski, 2018). It should be noted that it is "a form of cooperation between the municipality and residents based on their participation and involvement of their own forces and resources." In contrast to the first two tools, the legislator imposed on municipal authorities the obligation to regulate the principles of the local initiative, which makes the right to initiate cooperation belong to residents. Within the framework of a local initiative, residents both propose an idea for the implementation of a specific project and undertake to participate in its implementation. This participation may consist of community service, monetary or in-kind benefits.

In this case, even more strongly than in the case of village founds, involved residents are the initiators of activities and actually participate in the performance of public tasks. The subject of the application for a local initiative may be, for example, activities supporting the development of local communities and communities (e.g., construction, expansion or renovation of municipal infrastructure); charitable activities and, inter alia, maintaining and disseminating national tradition, cultivating Polishness; activities in the field of education, education and upbringing; activities in the field of supporting and disseminating physical culture and tourism and sightseeing; activities concerning ecology and animal protection and protection of natural heritage.

Comparison of civic budget, village fund and local initiative characteristics is encapsulated in Table 1.

Table 1. Comparison of civic budget, village fund and local initiative characteristics

	Civic Budget (B)	Village Fund (F)	Local Initiative (I)
Where?	All municipalities	Only municipalities with "solectwo"	All municipalities
Mandatory?	Partially (big cities)	No	Yes
Who decides to launch?	Municipal authorities	Municipal authorities when asked by residents	Residents
Main task area?	Pointed by the municipality authorities	Connected with upgrading local quality of life	Law regulated municipality tasks
Project proposal authors?	Residents	Residents	Residents
Limit of funds?	Only minimum in some cases	Law regulated (but not mandatory)	No
Project size?	dependent on municipal authorities	Small	Dependent on municipal authorities
Form of selection of the proposed projects?	Ballot	Deliberation and voting	Deliberation and contracting
Participation of residents in project implementation?	Usually not present	Possible	Mandatory

3.2. Data Analysis

All municipal governments in Poland (2,496) were analyzed, including also 19 districts of the capital city of Warsaw (functioning in a manner similar to municipalities in the implementation of local initiatives and civic budget).

It is important to note that while the civic budget and local initiative can be implemented by all surveyed entities, the village fund can only be implemented in those municipalities that have separate auxiliary units in the form of sołectos. In Poland in 2020-2022 there were 2,173 of them (including 11 cities). This means that civic budgets were implemented in about 13-14% of the units, local initiatives in about 9% of the units, and village funds in about 50% of the municipalities (see Table 2).

Table 2. Scale of use of selected forms of public participation in municipalities in 2020-2022

	2020	2021	2022
Civic budget	340	319	359
Village fund	1,551	1,494	1,472
Local initiative	227	205	205

Of course, it should not be forgotten that individual solutions can occur simultaneously within a single local government unit. Table 3 presents detailed data on the co-occurrence of individual public participation tools in Polish municipalities.

Table 3. Scale of use of combinations of selected forms of public participation in municipalities in 2020-2022.

	2020	2021	2022
Only civic budget (B)	151	147	156
Civic budget and local initiative (BI)	69	60	77
Only village fund (F)	1,330	1,298	1,266
Village fund and civic budget (FB)	101	94	109
Village fund, civic budget and local initiative (FBI)	19	18	17
Village fund and local initiative (FI)	101	84	80
Only local initiative (I)	38	43	31
None of them	687	752	760

As can be seen, about 30% of municipalities in Poland do not use any of the previously mentioned tools in their activities. On the other hand, about 1.3% of the surveyed municipalities (32) used all three forms at least once during the period under review. Among them were three urban municipalities with separate sołectwos as auxiliary units. The vast majority of municipalities use only one of the public participation tools in question, with the village fund dominating due to the number of municipalities located in rural areas. Interestingly, about 1.5% of municipalities use only the local initiative.

Tables 4-6 present detailed data on the use of various forms of public participation in 2020-2022 in urban, rural, urban-rural municipalities and districts of the city of Warsaw. Differences between different types of local government units are evident here.

In the case of urban municipalities, about 60% of them use at least one of the forms of participation discussed, with about 65% of them using only participatory budgeting. In addition, about 20% of these municipalities use participatory budgeting and local initiative.

In the case of rural municipalities, between 65% and 70% annually involve residents in the public participation processes studied. As it was mentioned earlier, the vast majority (about 90%) here is made up only of village funds.

An interesting situation can be observed in the case of urban-rural municipalities. This is the group of municipalities in which various forms of public participation are most often used. At least one of the surveyed tools was used annually by more than 80% of them. Due to their specifics, more than 65% of these municipalities used only village funds and a further several percent used village funds and participatory budgeting.

Table 4. Scale of use of selected forms of public participation in municipalities in 2020

Municipality	F	FB	FI	FBI	B	BI	I
Urban	3	2	0	2	124	31	12
Rural	935	9	73	1	7	2	20
Urban-rural	392	90	28	16	15	2	6
Warsaw districts	0	0	0	0	5	14	0

Table 5. Scale of use of selected forms of public participation in municipalities in 2021

Municipality	F	FB	FI	FBI	B	BI	I
Urban	3	3	0	2	115	35	10
Rural	889	12	58	2	8	0	29
Urban-rural	406	79	26	14	9	2	4
Warsaw districts	0	0	0	0	5	13	0

Table 6. Scale of use of selected forms of public participation in municipalities in 2022

Municipality	F	FB	FI	FBI	B	BI	I
Urban	3	5	0	2	130	38	7
Rural	872	12	57	2	9	0	20
Urban-rural	391	92	23	13	11	6	4
Warsaw districts	0	0	0	0	6	13	0

Figures 1-3 show the spatial distribution of municipalities using each form of public participation. As can be seen, there are clusters of municipalities throughout the country that have not introduced any of the three solutions (gray). The distribution of municipalities using village funds appears to be even across the country. As can be seen, participatory budgets are mainly found in the western part of the country, which is mainly due to the concentration of urban centers in these areas. Local initiative, on the other hand, is used mainly in the provinces of southwestern Poland, central Poland and Pomerania. Concentrations of municipalities using this solution are evident.
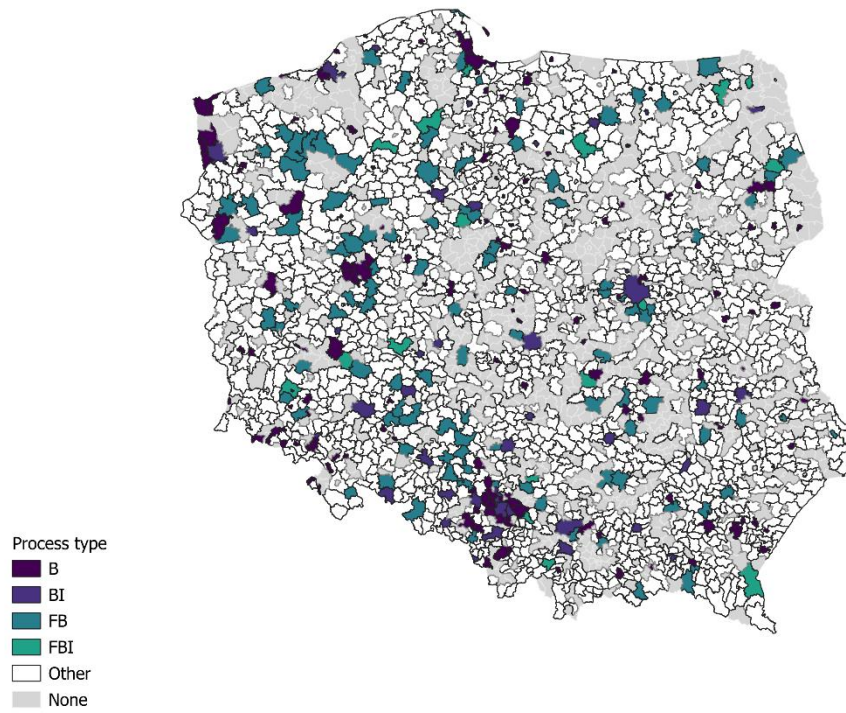
Figure 1. Territorial distribution of processes with civic budget
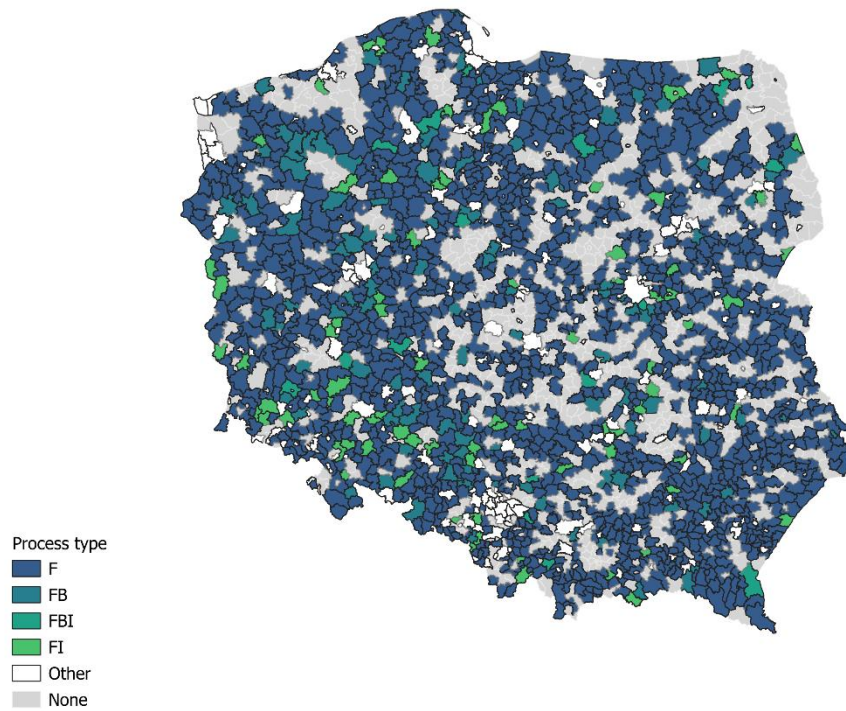
Figure 2. Territorial distribution of processes with village fund
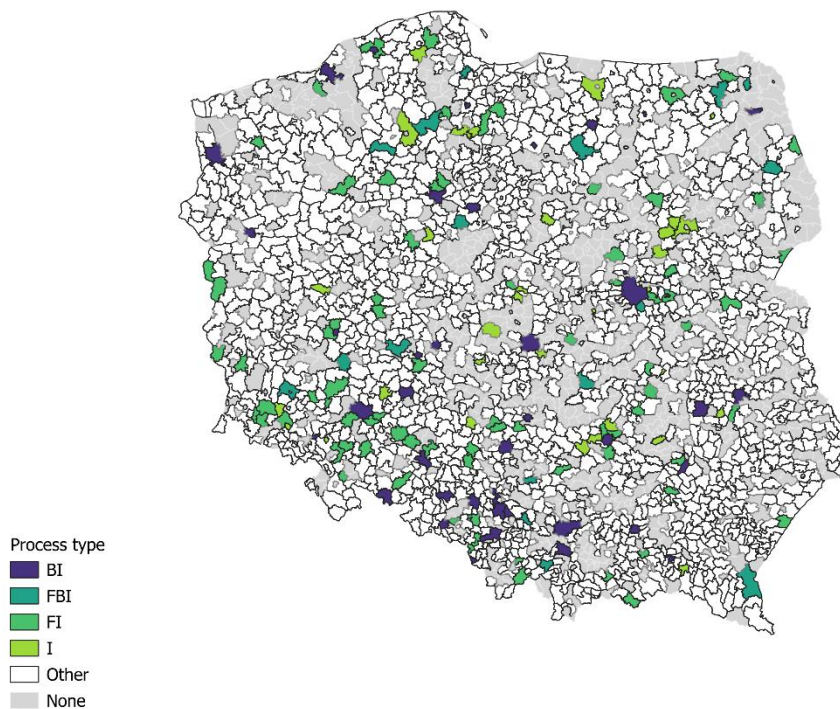
Figure 3. Territorial distribution of processes with local initiative

4. Discussion

Comparing the studied public participation tools, it is important to note their complementarity (RQ1). While participatory budgets are aimed at large communities in which individuals play leadership roles, and residents' involvement in participation revolves around the process of preparing a project proposal and voting, village council funds are aimed at small local communities that are also able to participate in project implementation. On the other hand, at the opposite end to participatory budgets are local initiatives, in which small groups of residents take responsibility for the entire process from design to implementation. Thus, thanks to this differentiation, it is possible to activate different groups of residents, which is what some local governments are doing in practice.

In the years under study, a gradual decrease in the percentage of municipalities using the surveyed public participation tools is visible, from 71% to 69% of all municipalities in Poland (RQ2). Undoubtedly, such changes were influenced by the crises recorded during this period, as they negatively affected the finances of municipalities. In the analyses presented, it is evident, despite the widespread use of participatory budgets, that rural and urban-rural municipalities mainly use village funds (RQ2). This situation may be due to a better "fit" of village funds to the needs of small rural communities. A dozen or so auxiliary units in a rural municipality (sołectwo) may have such a variety of needs that the logical solution to meet them all is a village fund.

In the case of urban-rural municipalities, it turns out that the village fund for the rural area of the municipality occurs far more often than the participatory budget. The reason for

this may be the decidedly weaker availability of public services in rural areas, which may lead to a desire to "compensate" for these inconveniences with investments from the village fund (RQ2). Due to the fact that the urban area in urban-rural municipalities cannot be covered by the village fund, a number of municipalities decide (about 20% of the total) to introduce a participatory budget as a supplement to the participation mechanism (RQ3).

Importantly, it usually applies to the entire area of the municipality - including the areas covered by the village fund. In practice, it is possible to introduce solutions similar to village funds for auxiliary units of the municipality located in an urban area, which can replace the participatory budget. Unfortunately, data on the implementation of such solutions nationwide is not currently available.

A big negative surprise, however, may be the relatively low popularity of participatory budgets in urban municipalities (RQ2). Previous studies have indicated that cities are usually characterized by a high potential for introducing such solutions. This potential is due to the existence of strong pressure from residents to implement such solutions, a high level of social capital and the willingness of cities to introduce good governance practices.

Changes in the number of municipalities implementing participatory budgets in 2020-2022 may also be a consequence of the crises occurring during this period. However, the increase in the number of municipalities in 2022 using participatory budgets indicates that there is no reduction in the implementation of this form of public participation, unlike village funds.

The least used public participation tool turns out to be the local initiative (RQ2, RQ4). This is a significant surprise, because despite the very low formalization, high flexibility of the process, and the lack of need for significant involvement on the part of the municipal administration, residents of most municipalities do not use this solution. It should be noted that this is usually a complementary tool to one of the above (RQ3). In local governments using this tool, more than 70% of municipalities introduce other public participation tools in parallel (RQ4).

The problem here may be, on the one hand, the lack of knowledge about the possibility of using the local initiative and the need for residents to engage their own forces, time and resources. However, bearing in mind the strongly developed structure of non-governmental organizations in Poland, and thus of people active in various areas of social life, it can be expected that this form will be used to a greater extent in the future.

The territorial distribution of the use of particular forms of public participation depends largely on the specifics of the region. The use of village funds is widespread nationwide (RQ5). Participatory budgets, on the other hand, are introduced most often in the western part of the country, which is mainly due to the concentration of urban centers in these areas (RQ5). Local initiative is used mainly in the provinces of southwestern Poland, central Poland and Pomerania. It should also be noted that the observed clusters of municipalities using the local initiative mechanism may be indicative of ongoing processes of "learning from others" new solutions. A similar process could be observed in the case of the spread of village funds.

5. Conclusions

Poland is one of the few countries with such broad statutory regulations on public participation processes. This should promote active use by citizens of the opportunities thus created. The analysis showed that about 70% of all municipalities use at least one of the analyzed forms of public participation. As noted, the village fund dominates among them, which is due to the structure of the types of municipalities in Poland. For urban and urban-rural municipalities, interest in using other forms of public participation is lower. A negative surprise is the very limited use of local initiatives which, unlike the other two forms, are characterized by a very simplified procedure and do not require the involvement of a large part of the local community.

It should be pointed out, of course, that due to the breadth of the problem and the partial lack of data, the article does not undertake an analysis of the direction of spending and the scale of spending on individual areas of municipal activity. This article can be a starting point for further discussion on the use of individual forms of public participation both in Poland and in other countries that would like to model themselves on Polish solutions.

Conflict of interest: none.

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An Overview on Sustainable Competitiveness in the Visegrad Group Countries – Comparative Analysis

Klaudia PASKUDZKA[1], Anna Sylwia KOWALSKA[1], Anna OLSZAŃSKA[1], Joanna SZYMAŃSKA[1] and Martin KRÁL[2]*

[1] Wroclaw University of Economics and Business, Wroclaw, Poland; klaudia.paskudzka@ue.wroc.pl; anna.kowalska@ue.wroc.pl; anna.olszańska@ue.wroc.pl; joanna.szymańska@ue.wroc.pl

[2] University of Hradec Králové, Hradec Králové, Czechia; martin.kral.2@uhk.cz

* Corresponding author: martin.kral.2@uhk.cz

Abstract: The article provides a comprehensive comparative analysis of the sustainable competitiveness of the Visegrad Group (V4) countries, including the Czech Republic, Poland, Slovakia, and Hungary, focusing on the economic aspects of sustainable production. The study utilizes the Global Sustainable Competitiveness Index (GSCI), based on 190 measurable and comparable quantitative indicators, categorized into dimensions such as Natural Capital, Social Capital, Intellectual Capital, Resource Efficiency, Economic Sustainability, and Governance Performance. The analysis reveals that all Visegrad Group countries have made significant progress in integrating sustainability principles into their policies and economic practices from 2013 to 2023, although differences in the intensity of these changes are noticeable. The Czech Republic has shown the highest growth dynamics in the GSCI, while Hungary recorded the lowest index values. Furthermore, the article highlights how updates and revisions to the sustainable competitiveness model, including the integration of new indicators and methodological improvements, have contributed to better reflecting the countries' performance in sustainability. In conclusion, the analysis underscores that the Visegrad Group countries are committed to promoting sustainable development, balancing economic growth with environmental protection and social progress, despite challenges such as economic disparities and environmental degradation.

Keywords: sustainable competitiveness; Visegrad Group Countries; GSCI

JEL Classification: L60; O11; O21

1. Introduction

Sustainable competitiveness has become an increasingly important concept in the field of economics, as it focuses on not only improving resource productivity but also emphasizes social sustainability and the responsible use of the environment (FAO, 2017). The Visegrad Group (V4) countries, including Czechia, Poland, Slovakia, and Hungary, have gained attention for their economic performance and potential for growth (Kowalska et al., 2018; Kowalska & Kovárník, 2018). The economic aspects of Global Sustainable Competitiveness in the Visegrad Group countries are multifaceted. Falkowski (2023) highlights the potential for improvement in sustainable competitiveness through the implementation of the European Green Deal, despite short-term costs.

As indicated by (Bogoslov et al., 2022), the European Green Deal aims to transform the EU into a well-functioning and resilient society based on a competitive economy and ecological environment. However, (Chatzistamoulou & Kounetas, 2023) point out the negative impact of the European Green Deal on entrepreneurship and competition. According to them, the European Green Deal may prioritize the environmental dimension over the free market and introduce government interventions and regulations that could disrupt entrepreneurship and competition. Despite this criticism, (Szabó et al., 2022) consider the European Green Deal crucial for achieving long-term sustainable development goals.

Dziembała, (2020) emphasizes the need for a diversified EU cohesion policy to promote sustainable competitiveness, particularly in less developed regions. Bačík, et al., (2019) assesses the economic performance and competitiveness of the V4 countries, with the Czech Republic standing out as the most successful. Chetverikova, (2020) provides a comprehensive analysis of the structural changes in the economies of the Visegrad Group, including industry and employment structure, and the innovation sphere. These studies collectively underscore the importance of sustainable development, regional disparities, and economic performance in shaping the sustainable competitiveness of the Visegrad Group countries.

The Global Sustainable Competitiveness Index is influenced by a range of factors at both micro and macro levels, including added value creation, quality management, and social responsibility (Okunevičiūtė Neverauskienė et al., 2020). This index is also shaped by the triple bottom line concept, which balances economic prosperity, environmental issues, and social sustainability (Herciu & Ogrean, 2014). Higher competitiveness, as measured by the Global Competitiveness Index, is linked to improved economic performance and sustainability (Rajnoha & Lesnikova, 2022). The concept of Sustainable Competitiveness integrates economic, social, and environmental sustainability, and is measured by the Sustainability Adjusted Global Competitiveness Index (Doyle & Perez-Alaniz, 2017).

This article explores the economic aspects of sustainable production in the Visegrad countries in comparative analysis.

2. Methodology

The study used statistical materials published in the form of The Global Sustainable Competitiveness Index. The GSCI considers the issues of 190 measurable and comparable quantitative indicators (SolAbility, 2023). These indicators are categorized into dimensions that contribute to a country's success: Natural Capital, Social Capital, Intellectual Capital, Resource Efficiency, Economic Sustainability and Governance Performance (Figure 1).

More than 90% of the indicators used to assess sustainable competitiveness are purely quantitative performance metrics. Data sources were selected based on their reliability and the availability of global data. The majority of indicators were sourced from the most important organizations in the world incl. the World Bank's indicator database, with additional datasets and indicators obtained from various UN agencies and the IMF. Furthermore, reputable external indexes published by non-governmental organizations were incorporated, such as Transparency International, Reporters Without Borders, The New Economics Foundation, The Institute for Economics and Peace, the Fund For Peace, and the

Figure 1. Sustainable Competitiveness elements (own processing based on (SolAbility, 2023))

V-Dem Project. The subject of the analysis included data on food security from Poland, the Czech Republic, Hungary, and Slovakia. The basic time range of data covers the years 2013-2023 (some analyses, due to lack of data, start in 2014). The article uses the basic methods of statistical analysis of data, i.e., Pearson's correlation, trend lines, and dynamics indicators. Time series of the GSCI, its value in each country, was presented for the countries of the Visegrad Group. A trend function line and a determination coefficient R^2 was determined for them. It is generally accepted that $R^2 \geq 0.70$ fits the data well.

3. Results and Discussion

Sustainable competitiveness in the Visegrad Group countries, comprising Poland, Czech Republic, Slovakia, and Hungary, is a multifaceted concept encompassing various economic, social, and environmental dimensions. These countries have made significant strides in integrating sustainability principles into their economic policies and practices, aiming to achieve long-term economic growth while preserving natural resources and promoting social well-being.

The analysis of The Global Sustainable Competitiveness Index in the Visegrad countries, over the past ten years, indicates that it has changed significantly. However, in each of these countries, he intensity of those changes varied. Although the countries analyzed were chosen for comparison due to their numerous similarities, there is a noticeable disparity in their level of sustainable competitiveness. The GSCI developed most dynamically in Czechia, where also it was the highest (for the most of the studied period). The worst situation has been noticed in Hungary, where it recorded the lowest values of the GSCI for most of the studied period (Figure 2).

In Czechia, in 2013-2023, the value of GSCI increased by almost 2 points, however, the largest increase, from 52.7 to 55.2 points was recorded in the years 2019-2020. After this period, there was a decrease 52.9 and 52.4 in 2022. The last year was better again and the GSCI increased. The average annual growth rate throughout the entire period studied was
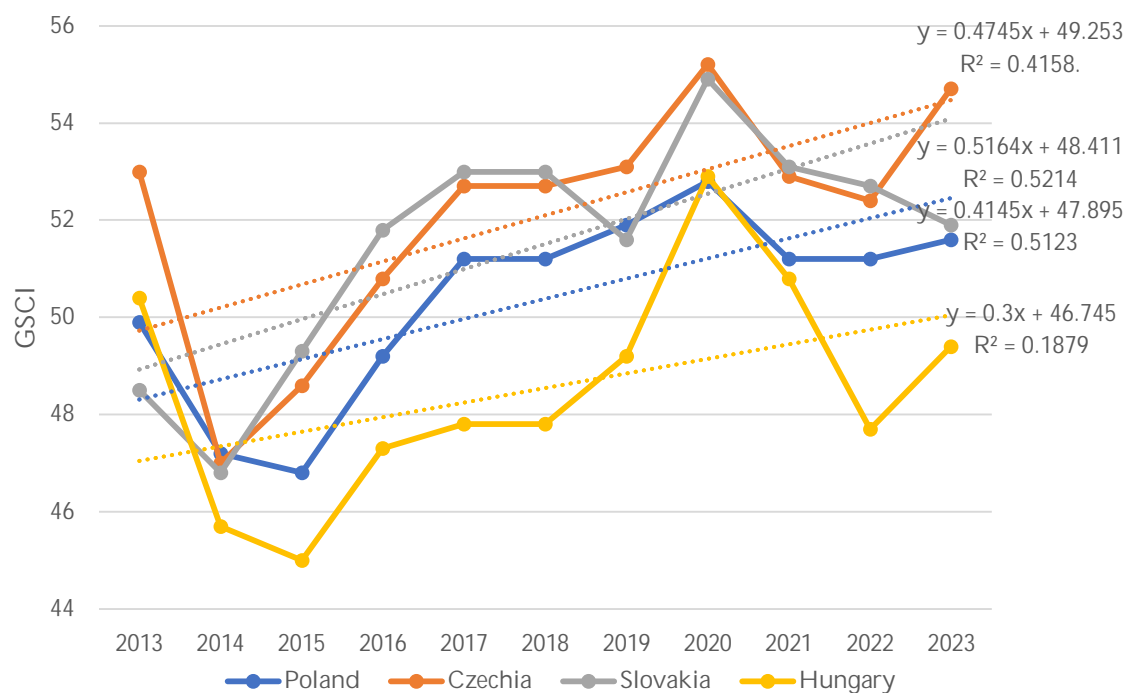
Figure 2. Values of Global Sustainable Competitiveness Index in Visegrad Group countries in years 2013-2023 – scale from 0 to 100 (SolAbility, 2013, 2014, 2015, 2016, 2017, 2018, 2018, 2019, 2019, 2020, 2021, 2022, 2023)

the highest compared to other countries of the Group. In Czechia, on average, in 2013-2023 the GSCI increased annually by almost 0.5 points, with a good fit at $R^2 = 0.42$. Czechia stands out as the sole country in the group where the GSCI has significantly decreased. Other countries of the Group recorded an increase or slight fluctuations in GSCI throughout the entire period studied. The GSCI in Slovakia increased very intensively. During the analyzed period, the GSCI in this country became much larger, for about 6.6% (from 48.5 points to almost 51.9). In this case, the average annual increase in sustainable competitiveness area during the period under consideration is over 0,5 points, with a good fit ($R^2 = 0.52$). Poland also showed a good fit of the trend line ($R^2 = 0.51$) over the period considered. In the case of this country, the GSCI has increased since 2013 by 3.3% (from over 49.9 points to 51.6). Despite the growing tendency, the average annual growth of the sustainable competitiveness area amounted to about 0.4 points. What is interesting, the GSCI in Hungary was the lowest among the countries surveyed in 2023 but it was not in 2013. At the beginning of the analyzed period, the index rated 50.4 points and it was on the second place, just behind the Czechia. Hungary is the only country which shows the decrease in GSCI. In the analyzed period, in this country it decreased for almost 2% (from 50.4 points to almost 49.4). The average annual rate was decreasing by about 0.3 points. Moreover, the trend line fit in this case was very low.

The components of The Global Sustainable Competitiveness Index are: Natural Capital, Social Capital, Intellectual Capital, Resource Efficiency, Economic Sustainability and Governance Performance and they were also assessed (Figure 3). Over years, the Sustainable Competitiveness model underwent updates and revisions to adapt to changes in global trends, emerging issues, and advancements in sustainability metrics. These changes have

included such areas as integration of new indicators, methodological refinements and data sources. The model has incorporated additional indicators to better capture the sustainability performance of countries, reflecting evolving priorities and challenges. Moreover, there have been adjustments to the methodology used for data collection, analysis, and interpretation to enhance the accuracy and reliability of the assessment. Furthermore, the model has utilized more recent and comprehensive datasets to provide a more current and nuanced understanding of sustainability trends and challenges.

Overall, the changes in the Sustainable Competitiveness model aimed to improve its effectiveness in measuring and monitoring the sustainability performance of countries and informing policy decisions at national and international levels.
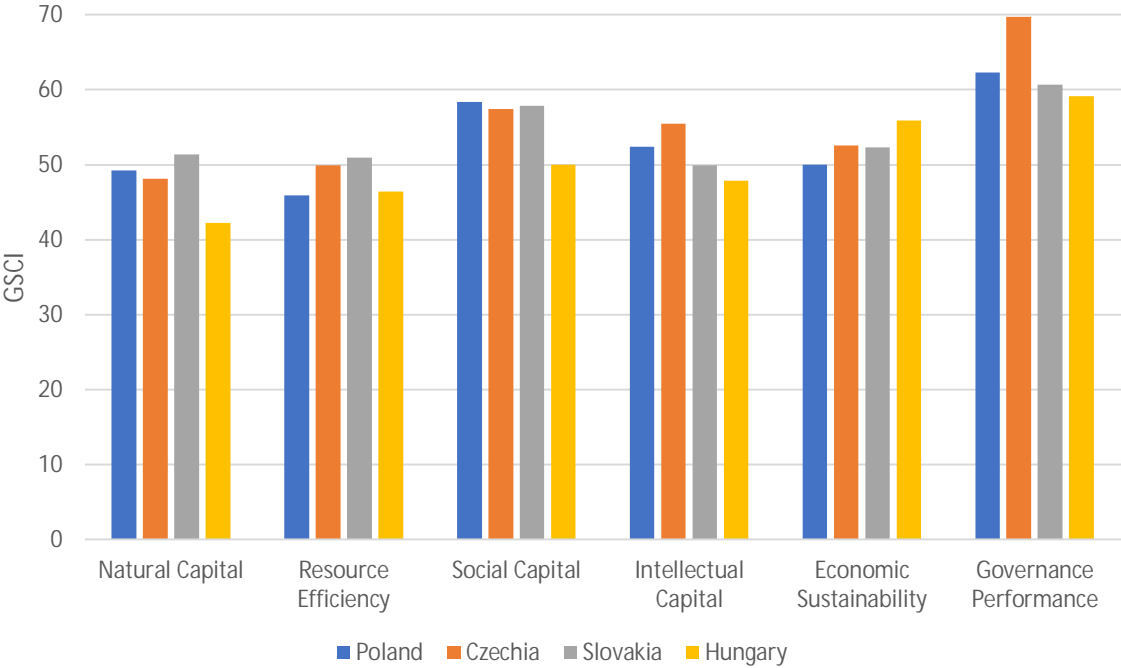
Figure 3. The Global Sustainable Competitiveness Index components in Visegrad Group countries in 2023 in points (SolAbility, 2023)

The natural capital encompasses various elements such as land area, population, geographical features, climate, biodiversity, and the abundance of natural resources, both renewable and non-renewable. It also considers the extent of depletion or degradation of these resources. These factors, alongside the depletion of non-renewable resources caused by human activities and climate change, determine the potential for sustaining the well-being of a nation's population and economy in the future. In 2023 Slovakia scored the highest result of the Visegrad Group. Countries. It is because of its diverse geography, favorable climate, and abundant water resources. The country's rich biodiversity, supported by various ecosystems, benefits from conservation efforts and sustainable resource management practices. Additionally, this country scored also the highest in the field of resource efficiency. Greater resource efficiency correlates with increased economic competitiveness. Due to Slovakia's effective utilization of available resources, this country is contributing to enhanced economic competitiveness and sustainability, especially among the Group countries. On the

other hand, any economic downturns have a detrimental impact on social capital, which is the next component of the GSCI. With reduced financial resources allocated to social aspects such as health and community development, coupled with increased crime rates and individual despair, the long-term competitiveness of a nation's economy is negatively affected. Poland is the country that scored the highest result. The key aspect is the effective utilization of available resources in Poland, such as human, technological, natural, and financial resources. Additionally, there is a strong emphasis on optimizing resource management practices, both domestically and in imports. This efficient resource management contributes to operational competitiveness, particularly in a world where resources are increasingly constrained. What is really interesting, the intellectual capital area is the highest in Czechia. It pertains to the capacity to create wealth and employment opportunities by fostering innovation and cultivating value-added sectors within the global marketplace. Furthermore, governance performance is the highest in Czechia too. It involves establishing a framework that ensures sustained and sustainable wealth creation through the allocation of resources, development of infrastructure, guidance on market dynamics, and structuring of employment opportunities. It is particularly strong in Czechia due to its effective framework for allocating resources, well-developed infrastructure, guidance on market dynamics, and structuring of employment opportunities. The last but not least, economic sustainability is the only field of the GSCI where Hungary scored the highest. Economic sustainability and competitiveness indicate the capacity to create wealth by pursuing sustainable economic growth and leveraging all available opportunities. In Hungary, a well-educated and skilled workforce can drive productivity and innovation, leading to higher economic sustainability and competitiveness.

Nowadays The Sustainable Competitiveness Index relies on 190 measurable indicators (not 73 like in 2013) categorized into 6 pillars (not 4 like in 2013). These indicators have been standardized to ensure comparability. Additionally, a trend analysis of performance data from the past 5 years has been conducted to generate a secondary score, providing insights into both the present status and future prospects of a country's sustainable competitiveness.

5. Conclusions

In summary, the following observations can be made:

- Slovakia stands out for its rich natural capital and high resource efficiency, resulting from its diverse geography, favorable climate, and abundant water resources.
- Poland achieves the highest scores in terms of social capital, reflecting the effective utilization of available human resources and emphasis on optimizing resource management practices.
- Czech Republic excels in the area of intellectual capital and management efficiency, attributed to effective resource management, well-developed infrastructure, and a conducive climate for innovation.

- Hungary distinguishes itself in the field of economic sustainability, indicating the ability to generate wealth through sustainable economic development and the utilization of available opportunities.

In recent years, the Visegrad Group countries have focused on enhancing their natural capital by implementing policies to protect and conserve biodiversity, forests, and water resources. They have also emphasized resource efficiency, aiming to optimize the use of available resources while minimizing waste and environmental impact. Additionally, efforts to strengthen social capital have included investments in healthcare, education, and social welfare programs to improve quality of life and ensure social inclusion.

Governance performance plays a crucial role in sustainable competitiveness, with the Visegrad Group countries striving to establish transparent and accountable governance frameworks that promote sustainable development. This includes measures to combat corruption, strengthen the rule of law, and enhance institutional capacity to address environmental and social challenges effectively.

All things considered, the Visegrad Group countries are actively working to enhance their sustainable competitiveness by balancing economic development with environmental protection and social progress. While facing various challenges, such as economic disparities and environmental degradation, these countries are committed to advancing sustainable development goals and fostering a resilient and inclusive economy for future generations. In conclusion, the analysis conducted in this paper sheds light on the economic aspects of sustainable competitiveness in the Visegrad countries. Further research and focus on sustainable competitiveness are crucial for facilitating economic growth and ensuring a prosperous future for the Visegrad countries.

Conflict of interest: none.

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DEA with Linear Object Function

Jan PELIKÁN

University of economics Prague, Prague, Czech Republic; pelikan@vse.cz

Abstract: The classic DEA model maximizes the ratio of aggregate output over aggregate input. If we denote the aggregated output as revenues and the aggregated input as costs, then the DEA model works with the ratio of revenues and costs. In the article, instead of the ratio of output over input, the difference between revenues and costs, i.e. profit, is used. It is shown that the fractional objective function and the difference between revenues and costs may differ in the optimal solution. In the proposed DEA model, the objective function is profit, that is, the difference between revenues and costs, so it is a linear objective function. The proposed linear objective function DEA model is demonstrated by a numerical example and the differences in results are shown. This model is also analyzed and its possible modifications are shown.

1. Introduction in DEA Models

The DEA method was proposed to measure and compare the efficiency of production units based on the outputs and inputs of these units. It is based on the calculation and optimization of efficiency ratios, which is the ratio of aggregate output over aggregate input (hereafter efficiency index). The DEA model was published in the work (Farrell, 1957) "Measuring the efficiency of decision-making units" and by (Charnes et al., 1978), (Charnes & Cooper, 1962), and (Jablonský & Dlouhý, 2004), is also referred to as the CCR model.

The model is based on a certain number of outputs and a certain number of inputs, the aggregated output is the weighted sum of these outputs, and similarly the aggregated input is the weighted sum of the inputs. Input and output weights are model variables. The number of inputs and outputs for the evaluated production units is the same. The DEA method was designed to measure and compare the efficiency of production units based on the outputs and inputs of these units. It is based on the calculation and optimization of efficiency ratios, which is the ratio of aggregate output over aggregate input (hereafter efficiency index).

The calculation is based on a certain number of outputs and a certain number of inputs, the aggregated output is the weighted sum of these outputs, and similarly the aggregated input is the weighted sum of the inputs. Input and output weights are model variables. The number of inputs and outputs for the evaluated production units is the same.

Suppose we have r inputs and s outputs for each unit. There are n production units. Let's denote the inputs of the h-th production unit $x_{1,h}, x_{2,h},...x_{r,h}$, and the outputs of it $y_{1,h}, y_{2,h},.., y_{s,h}$. By aggregated input we mean the sum $\sum_{j=1}^{r} v_j x_{j,h}$, where $v_1, v_2, ..., vr$ are the weights of

individual inputs. The aggregated output is the sum $\sum_{i=1}^{s} u_i y_{i,h}$ with the weights of the outputs $u_1, u_2,..., u_s$.

The aggregate efficiency index is then a share $I_h = \frac{\sum_{i=1}^{s} u_i\, y_{j,h}}{\sum_{j=1}^{r} v_j x_{j,h}}$.

The problem, however, is to determine the weights of inputs and outputs to maximized I_h; this can be done so that the values of I_k ($k = 1, 2, ..., n$) of the aggregate efficiency index all production units are at most 1.

Mathematical model DEA (h-th production unit) is (1), (2), (3):

$$I_h = \frac{\sum_{i=1}^{s} u_i\, y_{j,h}}{\sum_{j=1}^{r} v_j x_{j,h}} \longrightarrow max \tag{1}$$

$$I_k = \frac{\sum_{i=1}^{s} u_i\, y_{j,k}}{\sum_{j=1}^{r} v_j x_{j,k}} \leq 1, \qquad k = 1,2,...,n \tag{2}$$

$$u_i \geq 0, \quad i = 1,2,...s, \quad v_j \geq 0\, j = 1,2,...,r \tag{3}$$

Optimal value of I_h is efficiency value of DEA method of h-th production unit. DEA efficiency value of all production units we get by solving n DEA models (1), (2), (3). Weights u and v of each production unit can be different, value of those gives maximal value of I_h.

If the value I_h of production unit reaches the value 1, it is an effective production unit. The order of the production units according to the degree of efficiency is given by the sizes of the corresponding maximal I_h values, which are in the interval (0, 1>.

2. Comparison of Optimal Solutions of the Optimization Model with **Profit Index** and Profit as Object Function

Analysis of the optimal solution of the problem with the objective function the ratio of revenues and costs (further profit index) and with the objective function profit as the difference between revenues and costs.

In this paragraph we will show the difference in optimal solutions of both models. First, we need to state some notation.

Notation:
X is the convex set of feasible solutions,
$f(X)>0$ the revenue of $X \in X$,
$g(X)>0$ the costs of $X \in X$,
profit $z(X)=f(X)-g(X)$,
profit index $I(X)= f(X)/g(X)$,
X_0 maximizes $I(X)$ on X,
X' maximizes $z(X)$ on X.

Proposition.
a) If $z(X') > 0$ then $g(X') \geq g(X_0)$ and $f(X') \geq f(X_0)$,
b) if $z(X') < 0$ then $g(X') \leq g(X_0)$ and $f(X') \leq f(X_0)$,

c) if $z(X') = 0$ then $I(X_0) = I(X') = 1$ and X_0 and X' are optimal for both objective functions $z(X)$ and $I(X)$.

Providing $\frac{f(X_0)}{g(X_0)} > \frac{f(X')}{g(X')}$, it holds:

d) if $z(X') > 0$ then $g(X') > g(X_0)$ and $f(X') > f(X_0)$ (costs and revenue of X' are higher than costs and revenue of X_0),

e) if $z(X') < 0$ then $g(X') < g(X_0)$ and $f(X') < f(X_0)$ (costs and revenue of X' are lower than costs and revenue of X_0).

Proof.

Because X_0 maximizes the function $I(X)$ on X, so it holds

$$\frac{f(X_0)}{g(X_0)} \geq \frac{f(X')}{g(X')} \tag{6}$$

We easily see that from (6) follows next inequalities:

$\frac{f(X_0)}{g(X_0)} - 1 \geq \frac{f(X')}{g(X')} - 1$ and $\frac{f(X_0) - g(X_0)}{g(X_0)} \geq \frac{f(X') - g(X')}{g(X')}$ $\frac{f(X_0) - g(X_0)}{g(X_0)} \geq \frac{f(X') - g(X')}{g(X')}$

$$f(X') - g(X') \geq f(X_0) - g(X_0) \geq \frac{g(X_0)}{g(X')}(f(X') - g(X')). \tag{7}$$

From (7) it follows two cases: a) and b).

Case a):

If $z(X') = f(X') - g(X') > 0$ then it follows from (7) by dividing it by $f(X') - g(X')$ the inequalities $\frac{g(X_0)}{g(X')} \leq 1$ and $g(X_0) \leq g(X')$ and

$$f(X') - g(X') \geq f(X_0) - g(X_0) \geq f(X_0) - g(X')$$

and finally, $f(X') \geq f(X_0)$.

Costs $g(X_0)$ at the solution X_0 are not higher than costs $g(X')$ at X' (they can be lower see case d)) and the same for revenue $f(X_0)$ and $f(X')$.

Case b):

If $z(x') = f(X') - g(X') < 0$ then from (7) it follows by dividing it by $z(X') = f(X') - g(X')$ that $\frac{g(X_0)}{g(x')} \geq 1$ and $g(X_0) \geq g(x')$ Then

$$\frac{f(X_0)}{g(X_0)} \geq \frac{f(X')}{g(X')} \geq \frac{f(X')}{g(X_0)}$$
$$\text{hence} \quad f(X') \geq f(X_0).$$

Costs $g(X_0)$ at the solution X_0 are not lower than costs $g(X')$ at X' and the same for revenue $f(X_0)$ and $f(X')$.

Case c) is trivial.

Cases d) and e) follow from a) and b) such that in (6) we assume a strong inequality.

QED.

The presented proposition shows that as a result of maximizing the efficiency index we can get a different solution than profit maximization. In that case and for $z(X') > 0$, the maximum profit can be higher than the profit corresponding to the model solution maximizing the index profit. Based on this, a linear DEA model can be proposed, which unlike the classic DEA model, will maximize profit, i.e. the difference between revenues and costs.

3. DEA Model with Linear Object Function

Object function (8) maximizes profit of h-th production unit provided that the profit of all production units (including this one) does not exceed the given parameter H (9).

In the model (8), (9), (10) (11), the parameter H is used, representing the maximum achievable profit, if $H = 0$, then this condition would coincide with the condition (2) of the classic DEA model. In case that $H = 0$ the optimal solution is $v = 0$ and $u = 0$ for all production units and from it follows $p_h = 0$. This can be prevented by condition (10).

$$p_h = \sum_{i=1}^{s} u_i \, y_{j,h} - \sum_{j=1}^{r} v_j x_{j,h} \longrightarrow max \qquad (8)$$

$$p_k = \sum_{i=1}^{s} u_i \, y_{j,k} - \sum_{j=1}^{r} v_j x_{j,k} \leq H, \qquad k = 1,2,\dots,n \qquad (9)$$

$$\sum_{i=1}^{s} u_i + \sum_{j=1}^{r} v_j = 1 \qquad (10)$$

$$u_i \geq 0, \quad i = 1,2,\dots s, \quad v_j \geq 0 \; j = 1,2,\dots,r \qquad (11)$$

4. Example

The proposed linear DEA method is illustrated on the example of 13 production units, with three inputs (input1, input2 and input3) and two outputs (output1, output2). Input and output values are contained in Table 1. In Table 2 are the results of using the classic DEA method, linear DEA with value $H = 0$ and linear DEA with value $H = 1,000$. Two columns marked with DEA contains values I_h and the order of those values obtained by classical DEA model (1)-(3). Columns marked as $H = 0$ contains values p_h and the order of those values obtained by using linear DEA model (8)-(11) with $H = 0$. Similarly, the values in two columns labeled H = 1,000 are results of the linear DEA model (8)-(11) with the parameter $H = 1,000$.

Table 1. Example: set of production units

	input1	input2	input3	output1	output2
Z1	22.05	113.60	194.00	5,777	6
Z2	43.48	169.37	340.00	11,408	10
Z3	13.03	60.64	125	3,165	4
Z4	54.00	265.00	575.00	16,349	11
Z5	63.31	220.69	487.00	11,390	12
Z6	16.02	96.10	209.00	5,356	5
Z7	15.96	63.80	178.00	4,004	3
Z8	5.05	21.88	35.00	856	1
Z9	18.55	105.25	240.00	5,663	6
Z10	23.04	107.09	235.94	6,476	4
Z11	50.39	257.66	468.00	13,316	12
Z12	21.91	107.34	218.58	6,580	6
Z13	194.43	750.10	1,514.66	39,137	24

Table 2. Results of DEA and linear DEA

	DEA	DEA		*H = 0*	*H = 0*		*H = 1,000*	*H = 1,000*
	index of profit	Order		Profit	Order		Profit	Order
Z1	1	1-7		0	1-4		810.79	3
Z2	1	1-7		0	1-4		1,000	1-2
Z3	1	1-7		0	1-4		621.38	5
Z4	1	1-7		-16.387	5		140.13	7
Z5	0.868	12		-106.84	9		434.44	6
Z6	1	1-7		-41.37	6		701.53	4
Z7	0.9416	9		0	1-4		1,000	1-2
Z8	0.9045	11		-104.997	8		-95.6169	9
Z9	1	1-7		-107.063	10		-97.029	10
Z10	0.9612	8		-124.867	11		-113.866	11
Z11	0.9169	10		-177.734	12		-162.842	12
Z12	1	1-7		-34.898	7		-31.1432	8
Z13	0.774	13		-218.35	13		-198.081	13

In Table 2, differences in the order of the object function values of three modifications of DEA (the classical DEA, linear DEA with H = 0, linear DEA with H = 1,000) can be observed. For example, in classical DEA model there are 7 effective production units with value Ih = 0, while in the linear DEA model with H = 0 only 4 production units (value ph = 0) and for H = 1,000 two production units are effective (ph = 1,000). Production unit Z9 is effective by using classical DEA, but is not effective in the linear DEA models. Production unit Z13 is not effective in all three modifications DEA model.

The order of production units at three modifications is different, however their differences are not significant. It should be noted that findings from the example cannot be proven in general.

5. Conclusion

The article presents an alternative DEA method for measuring the efficiency of production units. It is based on the measurement of the efficiency of profit sizes, in contrast to the classic DEA method, which uses the ratio of revenues and costs (profit rates) for this measurement. The accompanying example shows the results of using both methods and compares the resulting requirements for the efficiency of the production units.

Conflict of interest: none.

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Product Governance Regime of MiFID II as the Managerial Application of the PDCA Cycle

Vladimír PETRÍK

Czech University of Life Sciences Prague, Prague, Czech Republic; petrikvladimir@pef.czu.cz

Abstract: Part of the investor protection regulation under MiFID II is product governance, which stipulates that securities dealers should only offer customers investment instruments that meet their needs and objectives and are compatible with the target market. This regulation requires regular evaluation, review and revision of the investment instruments offered in the light of the identified target markets and the offering system. The aim of this paper is to transform the requirements of product governance regulation in investment services as a governance and management role. The research question addressed the possibility of incorporating product governance regulation requirements into the PDCA cycle, which can be used to continuously improve investment service delivery processes. Secondary data included relevant information from Web of Science database articles and legal information on product governance regulation and the PDCA cycle. By analyzing this data, common elements were sought to interpret the requirements of product governance regulation using the PDCA cycle. The results suggest that it is possible to apply product governance requirements to the PDCA cycle and incorporate them into management practice of adherence to this regulation, particularly the process of offering investment instruments, creating opportunity for extracting business-related added value from regulation.

Keywords: continual improvement; investments; PDCA cycle; product governance; MiFID II; regulation

JEL Classification: D18; G18; M3

1. Introduction

According to the part of investor protection regulation referred to as product governance under MiFID II, only investment instruments that satisfy the requirement of a compatibility between the characteristics, objectives and needs of those customers and the so-called target market (characteristics) of the investment instruments should be offered to customers by investment firms. The purpose of this regulation is described in more detail in subsequent legislation which, inter alia, introduces requirements for regular assessment, review and revision of the investment instruments offered in the light of the identified target markets and the reviews of system of offering investment instruments. Such legislation imposes de facto a regulation of direct marketing of specific investment instruments to general public, as it was mentioned before, specific investment instruments should be offered only to relevant and compatible groups of clients. This "compatibility" is based on the target market definition covering several aspects. Moreover, the requirements for regular assessments are the part of regulation. As such regulation creates additional requirements on internal processes of

investment firms, it seems, especially in current VUCA world in association with disruption of financial sector, be inefficient and ineffective that process changes will be utilized only for regulatory purposes without harvesting the possible relationships to other, business oriented, activities of investment firm. This intention is also related to Regulation Technology (hereinafter referred to as "RegTech") industry that refers to the use of technology to facilitate compliance with regulatory requirements in various (financial in this case) industries.

In this research article, author intend to address the priority of utilization of regulatory requirements for fulfilling the business goals of investment firm.

The paper is structured to 4 sections. Firstly, this section, Introduction, provides a brief idea on researched topic, its relevancy and structure of the paper, accompanied by description of current body of knowledge pertinent to the goal of the paper. Second section describes methods and data used for the research. Third section of the paper is very important as it states the results and discussion of gathered evidence and knowledge. Last section, the Discussion, summarizes the researched topic and asserts future possible ways of research, expanding the knowledge and filling the research gap.

1.1. Product Governance under MiFID II

On 20 October 2011, the European Commission adopted a legislative proposal for the revision of MiFID which took the form of a revised Directive and a new Regulation. After more than two years of debate, the Directive 2014/65/EU of the European Parliament and of the Council of 15 May 2014 on markets in financial instruments and amending Directive 2002/92/EC and Directive 2011/61/EU (hereinafter as "MiFID II") repealing Directive 2004/39/EC, commonly referred to as MiFID II and MiFIR, was adopted by the European Parliament and the Council of the European Union. They were published in the EU Official Journal on 12 June 2014. Its aim is to enhance financial stability and investor protection while improving market efficiency and competition. MiFID II was approved by the European Parliament in 2014 and entered into force on January 3, 2018.

Relevant provisions of EU legislation pertinent to product governance are mainly following: Recital 71 of MiFID II; Article 9(3) of MiFID II; Article 16(3) of MiFID II; Article 24(1) and 24(2) of MiFID II and Articles 9 and 10 of the Commission Delegated Directive (EU) 2017/5932 (MiFID II Delegated Directive).

Regarding relevant local legislation, the basic legislation of investment services might be found Act No. 256/2004 Coll., on Capital Markets Undertaking Act, as amended (hereinafter as "Capital Markets Undertaking Act") and Decree No. 308/2017 Coll. on the more detailed regulation of certain rules in the provision of investment services issued by the Czech National Bank (hereinafter as "Decree 308/2017").

Important common denominator for application of product governance rules are Guidelines on MiFID II product governance requirements (ESMA, 2018) provided by European Securities and Markets Authority (hereinafter as „ESMA"). ESMA also scrutinize current guidelines based on the Common Supervisory Action conducted (ESMA, 2022; ESMA, 2023).

Product governance regulation aims to protect investors and promote market integrity by ensuring that financial products meet the needs of their intended target market and are

distributed appropriately. Colaert (2020) argue that The MiFID II product governance regime requires financial institutions to identify a target market of investors for all products they design or offer to clients, and to sell those products, as a rule, within the target market only. Although the aim of the regime – reducing misselling – is commendable, it has been implemented in a less than perfect way. After briefly describing the MiFID II product governance rules, this contribution discusses four major shortcomings, which have a detrimental effect on investor protection and the level playing field between financial institutions. The author proposes small amendments, which not only deal with those shortcomings, but also alleviate the compliance burden for the sector and lessen the regime's paternalistic edge. Hobza and Vondráčková (2019) add that while offering and selling unsuitable financial instruments has been so far prevented primarily by disclosure and other duties associated with the actual moment of sale of the financial instrument or the immediately preceding period, product governance covers the entire chain of interconnected steps from manufacturing of the financial instrument, through its sale to after-sales services. Related duties are imposed both on investment services providers that create, develop, issue or design financial instruments (i.e. manufacturers of financial instruments), as well as on investment services providers that offer, recommend or sell financial instruments to clients (i.e. distributors, as entities, incl. financial intermediaries that are in immediate contact with the client). Some of the duties apply only to manufacturers or distributors, others apply to both of them. From product governance measures, which have a common purpose to reduce the potential risk of failing to comply with investor protection rules throughout the life and sales cycle of a financial instrument, the biggest attention is paid to the target market of the financial instrument. Velliscig (2018) describes product governance as a change in retail customer protection: in this area of the law, an eventual convergence of solutions in client protection initiatives may be found. In a context oriented towards acting in accordance with the best interest of customers, EU legislator currently seeks a new "frontier" in the protection of retail customers and tends to develop new tools and strategies in addition to the disclosure of information and conduct of business rules, in order to remove potentially detrimental products from the market. This contribution examines the "product oversight and governance" principle intended to remedy problems associated with products misselling. In the details, this trend is analyzed with reference to the upcoming insurance distribution directive. Loonen and Pattisellano (2020) shows that product governance requirements were introduced to ensure that investment firms acting as manufacturers and/or distributors of financial products or instruments act in their clients' best interests throughout the product's life-cycle. MiFID II distinguishes between investment firms that manufacture financial instruments and those that distribute them. A firm qualifies as a manufacturer if it creates, develops, issues, or designs a financial product. A distributing investment firm is one that offers, recommends, or sells financial products to clients. Both manufacturers and distributors must have product governance arrangements and review processes in place. A key requirement of MiFID II is that investment firms must assess the target market for the investment products they distribute to clients. The distribution strategy should align with the target market of these products. This requirement applies to all clients, but the outcome of the product governance process may

differ depending on whether the products are offered to professional clients or retail clients. Certain arrangements may not be offered to retail clients, and some investment products may be eligible only for professional clients due to their complex risk profiles. When offering services to professional clients, the requirements for product governance may be less comprehensive compared to those for retail clients, as per ESMA guidelines. Overall, the aim of these product governance requirements is to enhance investor protection and ensure that financial products and services are suitable for their intended market and clients.

Where an investment firm needs to assess the target market, either in capacity of manufacturer or distributor, the firm must use the categories defined by ESMA (2018) in its guidelines. The guidelines for defining target market of investment instrument include factors such as:

- The type of (potential) clients to whom the product is targeted;
- The investment knowledge and experience present;
- The financial situation of the (potential) client with a focus on the ability to bear losses;
- The risk tolerance and compatibility of the risk/reward profile of the product with the target market; and
- The (potential) client's objectives and requirements (ESMA, 2018).

Marcacci (2017) sees the product governance regulation as a current example of European Regulatory Private Law ("hereinafter as "ERPL") phenomenon as it sets a world-wide (proto)normative framework regulating intra-firm processes. Under this premise, product governance rules may be viewed as the most recent example of ERPL. Ewing (2018) adds that product governance regime seems to have originated from the retail structured product environment. Rosie (2017) took its analysis to Australia and analyzed specific reforms related to "product regulation" laws. This article offers an analysis with economic insights into the UK's approach to product regulation, highlighting three main arguments. Firstly, it suggests that managing product governance is effectively a regulatory tactic aimed at preventing participants in the market from creating products that amplify flaws in the retail financial services market. Secondly, it argues that the powers to intervene in product governance should be activated only after market reactions to these governance practices are understood, and only if such intervention is likely to enhance the market's situation. Thirdly, it contends that interventions in product design (such as prohibiting products or dictating their conditions) become necessary only if market players do not adhere to the set standards of product design as mandated by product governance rules. Nonetheless, due to the practical challenges in strictly applying interventions based on violations of product governance rules, the article suggests that this link between product governance and intervention actions should serve as a general guideline rather than being formally encoded into legislation. Chong (2023) provided most current review when elaborated on Design and Distribution Obligations (hereinafter as "DDO") launched by Australian lawmakers. It is a framework aimed at enhancing protections for consumers through the introduction of new governance requirements for those issuing and distributing financial products. Although the DDO framework is still in its early stages, the Australian Securities and Investments Commission (hereinafter as "ASIC") has already

marked its enforcement as a principal focus area, a stance it plans to maintain in the coming years. This article evaluates the capability of the DDO framework to fulfill its primary goal of helping consumers' access suitable financial products while minimizing harm to them. This evaluation includes an analysis of the framework's structure, the policy discussions that shaped its formation, and how ASIC has applied the DDOs thus far. Representing the first in-depth academic investigation, this study scrutinizes both the strengths and weaknesses of the DDO framework's structure and gauges the effectiveness of ASIC's implementation efforts.

The core of product governance risk is misseling. Misselling can also take place with respect to regulated products, when consumers purchase what is unsuitable for them, advised or otherwise. Investors can also be let down by severe losses due to adverse market forces, such as during the onset of the global financial crisis, or as a result of investment managers' sub-optimal strategies (Chiu, 2021).

2.2. Continuous Improvement and PDCA Cycle

PDCA is the foundation of continuous improvement or kaizen. Teams implement improvements (Do) to achieve the targets. Then they measure (Check) the change to evaluate performance against the target. If the team has achieved a measurable gain, it standardizes (Act) the new method by updating the standardized work. This ensures the improvement is stable (Lean Enterprise Institute, 2022). PDCA is an iterative design and management method used in business for the control and continual improvement of processes and products. The steps of the cycle then become "plan" – "do" – "check" – "act". PDCA is a continuous improvement cycle, which includes iteration to continuously promote the excellence. The basis is written as "hypothesis" – "experiment" – "evaluation" or "plan" – "do" – "check". The last – act - step involves addressing any deviations in our process in order to continually improve our performance. This step takes the form of an analysis of the deviations in order to understand their root causes. The act step also provides a mechanism for continuous improvement (Liao, 2023). Unsuccessful PDCA applications are the result of many reasons such as: Poor studies on a current problem and its obstacle, erroneous data collection, wrong or improper use of quality tools, fail in defining root causes, insufficient analysis, process non-standardization, or no sharing learning experience before and after the PDCA implementation (Nguyen, 2020). Digitalization offers businesses a transformative opportunity for enhanced flexibility, agility, and customer responsiveness. Prioritizing quality in this transformation is crucial for customer-oriented success. The shift to digital practices is imperative to bridge the gap between traditional quality methods and a digitalized engineering value chain. While existing literature emphasizes quality and continuous improvement, insights into integrating quality practices in a digital context are limited. Addressing challenges like shorter time-to-market and increased complexity requires holistic adoption of digitalization across the PDCA quality cycle. The digitalization of quality practices should be viewed comprehensively throughout the value chain (Dutta et al., 2021). PDCA cycle is often accompanied in practice with other lean practices (Jimenez et al., 2019).

2.3. RegTech

"*Higher regulatory compliance requirements, fast and continuous changes in regulations and high digital dynamics in the financial markets are powering RegTech (regulatory technology), defined as technology-enabled innovation applied to the world of regulation, compliance, risk management, reporting and supervision*" (Grassi & Lanfranchi, 2022, p. 441). Europe's road to RegTech has rested upon four apparently unrelated pillars: (1) extensive reporting requirements imposed after the Global Financial Crisis to control systemic risk and change in financial sector behaviour; (2) strict data protection rules reflecting European cultural concerns about data privacy and protection; (3) the facilitation of open banking to enhance competition in banking and particularly payments; and (4) a legislative framework for digital identification to further the European Single Market (Buckley et al., 2020). Teichmann et al. (2023) argue that the Markets in Financial Instruments Directive (MiFID) II legislation, which has led to an increase in the number of RegTech companies. Although these systems of technology offer compelling compliance tools, they also pose significant risks: (1) inconsistent regulation, (2) cybersecurity and (3) legacy systems. Many banks have struggled to find solutions to keep up with increasing regulation and compliance (Solms, 2021).

3. Material and Methods

The aim of this paper is to transform the requirements of product governance regulation in investment services as a governance and management role.

Product governance requirements are connected also to repetitive regular reviews of given investment instruments and related processes. There is an implicit requirement for continual improvement in targeting adequate customers with offerings of investment instruments what evokes the PDCA cycle. Moreover, to fulfill product governance requirements, the various sets of data are needed and business model innovations based on digitalization of investment services creates these datasets. Answering of regulatory requirements by technology is the core of RegTech solutions. Moreover, the goal of investment firms is not only the fulfilling regulatory requirements, real business goals varies from increasing the shareholder value in long-term horizon to increasing the profit, margins or market share and product governance data might be useful for these goals.

Based on the literature review the following research gap has been identified: Absence of a structured analysis for understanding the interrelationship dynamics of purpose, data requirements and processes of product governance regulation in managerial practice and business goals of an investment firm.

The research question (RQ1) was: Is it possible to situate the requirements of product governance regulation within the PDCA cycle of continuous process improvement in the provision of investment services?

The paper uses secondary data. Secondary data represents relevant knowledge obtained from articles in the Web of Science database (hereinafter as "WoS"). As of November 1, 2023, small number of articles (14) resulting to key word query "product governance" in WoS (without any other filters on), with 4 of them excluded as they covered scope outside given product governance regime (insurance, pharmaceutical and forestry), resulting to 9 relevant

articles. Furthermore, secondary data on product governance regulation and PDCA cycle were used to answer RQ1. Through the analysis of these concepts and their subsequent generalization and synthesis, common elements were sought to interpret product governance requirements through the lens of the PDCA cycle.

The method of qualitative content analysis (hereinafter as "QCA") method was used on all data considered a product governance regulation (MiFID II, Capital Markets Undertaking Act, Decree 308/2017 and all cited ESMA sources). QCA can be a powerful method for analyzing legal documents and developing a deeper understanding of legal concepts and practices (Schreier, 2012). It allows researchers to identify patterns and themes within the data in a rigorous and systematic way, and to draw meaningful conclusions based on the analysis, mainly if it is accompanied by narrative, thematic and content analysis (Denzin & Lincoln, 2018). Following Barrett et al. (2005, p. 2), the QCA "*is not intended to celebrate the empirical detail*" but rather to identify new and emerging issues for study. The processing of data from WoS database might be characterized as textual narrative review, what includes characteristics (quality, findings, context, etc.) from reviewed literature (Lingeren et al. 2020). The sample strategy was systematic, but it was limited only to WoS database, what is also a limitation of the paper. The methods used in the article for both regulation and WoS sources are content analysis and thematic analysis of selected articles, followed by qualitative analysis (McColl-Kennedy et al., 2017).

4. Results

Results section is determined to explain the product governance regulation as a continuous development process with PDCA cycle application. In order to do so, first, the relevant provisions of product governance regulation of conducting activities by investment firm of regular, iterative manner, should be provided:

Investment firm in the role of *manufacturer* of investment instrument:

Sec. 9(1) of Decree 308/2017: Investment firm shall ensure that the person carrying out ongoing compliance monitoring (hereinafter referred to as "compliance") of the investment firm *regularly checks the system for the creation of investment instruments* in order to detect the risk that the securities dealer fails to comply with the obligations under Sections 8 to 10.

Sec. 10(3) of Decree 308/2017: Investment firm shall r*egularly evaluate the investment instrument it creates*, taking into account any events that could materially affect the potential risk to the designated target market. The investment firm shall consider whether the investment instrument continues to meet the needs, characteristics and objectives, including sustainability objectives, of the target market and whether it is distributed to the target market or to customers whose needs, characteristics and objectives are incompatible with the investment instrument.

Sec. 10(4) of Decree 308/2017: Investment firm shall evaluate an investment instrument before each subsequent issue or re-marketing if it is aware of an event that could materially affect the potential risk to investors and shall *assess at regular intervals whether the investment instrument is performing as anticipated.* Investment firm shall determine the *frequency of evaluation*

of an investment instrument based on relevant factors, including factors related to the complexity or innovation of the investment strategies being pursued.

Investment firm in the role of *distributor* of investment instrument:

Sec. 12(1) of Decree 308/2017: Investment firm shall *continuously verify and regularly evaluate its system for offering investment instruments* to ensure that it remains adequate and fit for purpose and, where necessary, take appropriate corrective action without undue delay.

Sec. 12(2) of Decree 308/2017: Investment firm shall *regularly evaluate the investment instrument it offers or recommends and the investment service it provides*, taking into account any events that could materially affect the potential risk to the intended target market. The securities dealer shall always assess whether the investment vehicle or investment service still meets the needs, characteristics and objectives, including sustainability objectives), of the intended target market and whether the intended sales strategy is still appropriate. Where a securities dealer determines that the target market for a particular investment vehicle or investment service has been incorrectly identified or that the investment vehicle or investment service no longer corresponds to the identified target market, in particular where the investment vehicle has become illiquid or highly volatile due to market changes, it shall change the target market and/or update the system for offering investment vehicles.

Sec. 12(3) of Decree 308/2017: Investment firm shall ensure that the compliance officer of the investment firm monitors the development and *regularly reviews the system for offering investment instruments and its significant changes* in order to detect any risk that the securities dealer fails to comply with the obligations under Sections 11 to 13.

There is no general obligation for manual or automated tracking prior to a marketing campaign. There is only an obligation to review the instrument before any further issue or re-launch if the product manufacturer identifies any event that could materially affect the potential risk to investors. If no such event is identified, a review need not be conducted on that occasion. However, other provisions imply an obligation to monitor the compatibility of sales with the target market on an ongoing or regular basis. With regard to the distributor of the product it applies in a similar vein. Such monitoring should be carried out on a regular basis depending on the complexity or innovative nature of the financial instrument or on anticipated changes in the target market. By this we mean an ongoing assessment at intervals to be set by the product manufacturer and the distributor, in practice always at least when a potential reason for reassessing the nature of the product in terms of the target market is identified. The practical design of the monitoring (whether automated or human) is a secondary consideration, and it is up to the manufacturer or distributor to decide which form of monitoring to choose. However, the intensity of the monitoring should increase depending on the product and the target market. The ESMA (2018) is clear in this respect on proportionality (e.g. articles 21, 38, 41 and 43 of the ESMA, 2018) and on the gradation (detail) of obligations depending on the nature of the service provided. The advice itself may contribute to monitoring. But even where it would not otherwise be provided, product management obligations imply a duty to communicate with the customer. In the review, the manufacturer and distributor of investment instruments should base the review on an assessment of the target market at the start of the product launch and should work with

aggregate data (in terms of sales and customers, by contrast, individual investment vehicle assessments will usually be necessary). As is clear from the articles 55 and 56 of ESMA (2018) attention should be paid in particular to sales outside the target market and in particular to the negative market. As also follows from the articles 57 and 58 of ESMA (2018), the review should, inter alia, assess these phenomena, their justification and, if necessary, suggest changes in the marketing strategy of the product concerned. The review should include, for more complex products, a questionnaire survey of a sample of customers for feedback (mentioned in Recital 20 of the MIFID II Implementing Directive and in article 57 of the ESMA, 2018). The frequency of the review is not fixed (e.g. annually) but is determined by the trader. It should be carried out periodically depending on the complexity or innovative nature of the financial instrument or on anticipated changes in the target market. Further actions to be taken by the manufacturer in the event of a 'triggering event' affecting the risk or return of the financial instrument (Czech National Bank, 2017; Decree 308/2017).

The key within these regular reviews is to, sufficiently, systematically and as scientifically as possible, analyze and explain all factors relevant for gaining objective results, i.e. regular reviews shall include decisions related to continual improvement opportunities and any need for changes to the product management processes (Herinková et al., 2023).

The idea of implementing PDCA cycle to compliance/regulatory issues is not totally new. The ISO 37301 standard provides a framework for organizations of all sizes and types to manage their compliance risks and ensure that they are operating within legal, ethical, and social boundaries. The standard is based on the PDCA cycle, which is a continuous improvement process used in many management systems. Such a model enables an organization to sufficiently establish, develop, implement, evaluate, and, if beneficial to the organization, maintain and continually improve processes. The common elements of a compliance management system fit comfortably into the four steps of the PDCA model. Leadership, governance, and culture are essential to the PDCA processes, so ISO 37301:2021 outlines understanding the organization and its context, planning, support, operation, performance evaluation, the role of leadership, and continual improvement.

Considering aforementioned thought on ISO 37301:2021 standard, it seems that it should be taken in account by relevant persons while defining product governance processes in an investment firm, as at the end of the day, the compliance with regulation is the minimum an investment firm must adhere to (as gaining additional business added value is not mandatory part of product governance regulation focus). If the requirements ISO 37301:2021 regarding management review inputs are applied to product governance process, it might be indicated that these review might include following attributes to identify any events that could materially affect the potential risk to the intended target market and adequacy of system for manufacturing/offering of investment instruments (this list is not full, as following the need for proportionality, one must take into an account the customer base, business model and investment instruments of an investment firm):

- The status of actions from previous reviews.
- Changes in external and internal issues that are relevant to the product governance process (e.g. target market, investment instrument, manufacturers of distributed investment instruments, 3rd parties to whom relevant processes are outsourced, etc.).
- Changes in needs and expectations of interested parties (manufacturers, distributors and especially the customers, etc.) that are relevant to the product governance process (e.g. target market, investment instrument).
- Information on the investment instruments performance, including trends in global, local and sectoral conditions, nonconformities, noncompliances and corrective actions (internal or external), monitoring and measurement results; audit results; supervision results.
- Opportunities for continual improvement.
- "Voice of the customers" via representative surveys of customer base.

The management review shall take into account the data infrastructure for making the conclusions (adequacy and effectiveness of existing controls and performance indicators).

5. Discussion

This chapter focuses on providing answers on research question RQ1, confronting it with existing knowledge and also sharing, in our opinion valuable, managerial implications.

The results indicate that it is indeed possible to transpose the requirements of product governance through the application of the PDCA cycle of continuous process improvement into managerial practice, in this case the process of offering specific investment instruments. This is based on regulation requirements. The current regulatory text does not provide complete direct guidance on how to measure and assess the adequacy of the investment instruments offered in terms of the identified target markets and the system of offering investment instruments. It is therefore essential to gather the "voice of the customer" in this area. It may be particularly important to collect customer information in the retention process. Customers themselves are an important part of the whole product management process, and the correctness of the target markets for investment instruments. Moreover, ISO 37301:2021 provides more detailed guidance on how to understand PDCA cycle within the management compliance systems. It is definitely a challenge to recognize the benefits and business value added by regulation and compliance with it, but there should be also a question whether we are trying to find it. As RegTech industry shows, technology might not be only utilized for ensuring compliance, but also to fulfilling the business goals of an organization. *"Compliance moves continuously in the focus of the corporate world, especially because of big business scandals with even bigger losses, but also as a result of the simultaneously increasing management and corporate liability for compliant organizational and operational action. A systematic and systemic approach such as the methodology of an integrated, holistic CMS seems to be an effective, practical instrument to ensure the 'duty to legality' in conjunction with the highest possible effectiveness of the compliance function within the 'second line of defense'"* (Westhausen, 2021, p. 348). Compliance is on ongoing process. Organizations can safeguard their integrity and

minimize noncompliance by embedding compliance in the values, behavior, and attitude of the organization and by keeping leadership involved, since they apply core values to follow throughout the enterprise. Organizations can develop and spread a positive culture of compliance by following ISO 37301:2021. This results in multifold benefits, including improved sustainability, enhanced business reputation, improved means of considering the expectations of interested parties, increased commitment to managing compliance risks, increased confidence from third parties in the organization's capacity to achieve success, and minimized risk of contravention. In our opinion, it is important to see regulatory changes and requirements as a management opportunity for innovation activities. Product governance regulation of investment firms should be recognized as the need for continual improvement in managing of misseling risk. In purchase behavior research, the personal dispositions of consumers can play a decisive role (Poler, 2022).

Regarding managerial implications, there are following issues worth to stress out for investment services providers:

- Regular reviews by product governance might be understood as a PDCA cycle of continual development of better offerings of investment instruments to customers.
- Regular reviews of target markets, based on sufficient data (surveys, data analysis, interviews, customers testing), leading to suitable offering of investments services, might be improving satisfaction of customers with chosen investments.
- Customers should be informed, why they are in the target market of some investment instruments (where is the intersection and compatibility between customers and investment instrument).
- Data regarding the opinions of customers who terminated investment services contract with an investment firm might poses valuable information for regular review of target market of investment instruments.

6. Conclusion

The research (e.g. Yeoh, 2019) highlights that only half of the EU Member States, including the UK, successfully incorporated MiFID II by its activation date on 3rd January 2018. In these initial phases, several initial challenges emerged, including issues related to reporting costs and charges, governance within firms, governance of products, reporting of transactions, ensuring best execution, and managing research. Given MIFID II's extensive reach and intricacy, many organizations struggled to meet their reporting requirements. And the regulatory pressure does not weaken. In response to these challenges, the lawmakers and regulators shall offer reassurances to firms that are making adequate efforts towards compliance, indicating that they would be met with fair treatment. Offering, recommending and selling the right investments to right customers is at the hearth of the product governance. This naturally requires having the right data about customers and subsequently leads to some kind of targeting. Targeting investment instruments more precisely to specific customers can enhance satisfaction and retention with current service providers. Personalization is crucial in improving customer experiences, but ethical handling of customer data is paramount for

privacy and security. Transparency in data usage and explicit customer consent build trust (Buckley et al., 2020). Legal protection of personal data is a challenge, requiring attention to fundamental rights. Ensuring the legal system adapts to the Digital Revolution is crucial for societal confidence. Precise data profiling is a key profit driver for the financial industry, but it poses risks such as data breaches, unfair pricing, and discrimination. The deeper and potentially more practically oriented research focused on target market obligations for financial products and their interaction with data protection rules, questioning if financial product governance rules may incentivize data profiling by service providers (Bednarz, 2022) might be a first avenue for future research. Leveraging technology and data analytics for personalized investment instruments creates a customer-centric experience that enhances satisfaction and retention, strengthening providers' positions. The naturally occurred gap between risks regulation aims to manage and real-life perception of these risks by customers is another line of inquiry for future research (e.g. finfluencer marketing and promoting specific investment instruments by influencers – does regulation keep up the trend?). In general, there is not much research covering product governance and the area is in the need of more research to shed some light on well-intended but hard to accomplish customer protection practices. In this context, the paper showed that to fulfill the idea of the regulation, it must be translated to managerial practice. Product governance regime is not a set of once in life obligations, it is never-ending process of ensuring that investment instruments matches the customers and risk of misseling is covered. At the end, significant deflection from this premise may lead to quick profits but the significant losses in long-term horizon. Moreover, investment landscape and customers are constantly changing and distributors should be able to "catch" it.

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Analysis of the Manufacturing Industry Using the Cobb-Douglas Production Function

Martin POZDÍLEK[1]*, Alena POZDÍLKOVÁ[1] and Martina HEDVIČÁKOVÁ[2]

[1] University of Pardubice, Pardubice, Czech Republic; martin.pozdilek@upce.cz; alena.pozdilkova@upce.cz

[2] University of Hradec Králové, Hradec Králové, Czech Republic; martina.hedvicakova@uhk.cz

* Corresponding author: martin.pozdilek@upce.cz

Abstract: The emergence of Industry 4.0 presents new challenges and opportunities in the field of economics and labor productivity. A key aspect of this transformation lies in the ability to accurately analyze the substitution of labor by capital, which is necessary for sound decision-making in managerial practice and for the formulation of policies that support innovation and economic growth. The Cobb-Douglas production method provides a robust analytical tool for examining this relationship within the context of Industry 4.0 and its impact on strategic decision-making regarding human resources and technology investments. The article aims to create a Cobb-Douglas production function for the manufacturing industry, both for the entire industry and for individual sectors in the Czech Republic. First, a correlation analysis will be performed, then the Cobb-Douglas production function will be constructed, and the relevant coefficients will be calculated using the least squares method. The degree of determination will then be verified for the entire model. The process will be carried out for individual manufacturing industry sectors in the next part. The different degrees of determination will be discussed in individual sectors and the whole.

Keywords: industry; correlation analysis; Cobb-Douglas production function; method of least squares; Industry 4.0

JEL Classification: D81; C69

1. Introduction

Industry plays an irreplaceable role in the Czech economy, accounting for almost a third of the total gross added value, which is the highest share in the EU28 countries. Despite the growing share of services in developed countries, the importance of the manufacturing industry in the Czech Republic remains significant. The manufacturing industry of the Czech Republic is highly developed and its sector accounts for roughly 23% of economic output (share in the creation of gross added value in 2022). The Czech Republic leads among European countries in the share of the manufacturing industry in gross added value, even surpassing Germany, Slovakia and Poland. Almost a quarter of total employment in the Czech Republic is in the manufacturing industry, which is also among the highest values in Europe (Ministerstvo průmyslu a obchodu, 2023).

The manufacturing industry in the Czech Republic is significantly export-oriented, which emphasizes its key role in the country's economy. The growth of foreign demand is very important for the Czech economy.

The Cobb Douglas production function is one of the key concepts of economic theory that is used to model the production process in industries. This function is particularly relevant in the context of the manufacturing industry, which represents a significant part of the economy of the Czech Republic.

Industry 4.0, as a modern initiative aimed at the automation and digitization of industrial processes, has a significant impact on the way production processes are organized in the Czech manufacturing industry. This trend encourages the substitution of labor for new technologies such as robotization, automation, and artificial intelligence, which affects the parameters of production functions (Hedvičáková & Král, 2021; Maresova et al., 2018).

The elasticity of substitution between labor and capital, referred to as σ (sigma), is used by economic theory as a measure of the substitutability of these factors in the production process. Early studies suggested that σ could be around 1, but more recent research presents mixed results. Estimates of the elasticity of substitution are sensitive to the methodology used and the data available (Procházková Ilinitchi et al., 2021).

The degree to replace capital and labor factor connections offers many variables (Chirinko, 2002; Knoblach & Stöckl, 2020) and there is a debate (Chirinko, 2008) about estimates of σ based on different short-run and long-run models, returns to productive factors in an open economy (Jones & Ruffin , 2008; Knoblach & Stöckl, 2020), the relationship between technology shocks and hours worked (Cantore et al., 2017; Knoblach & Stöckl, 2020), as well as industry transformation (Alvarez-Cuadrado et al., 2017; Knoblach & Stöckl, 2020).

2. Methodology

2.1. Correlation Analysis

A Spearman correlation coefficient is an important characteristic in evaluating the validity of tests because it determines how closely two related phenomena are captured together. Thus, it allows quantitative determination of how far the two similar orders are created. For the calculation, it is necessary to have a table in which you can specify individual correlated pairs, which are compared to the individual components of the correlation, the overall index, and the basic form of vector analysis. The result is a dimensionless number, which indicates the degree of correlation between individual freedom and the steam created for each pair of correlations.

2.2. Cobb-Douglas Product Function

In economics, the Cobb-Douglas production function is widely used to represent the relationship between inputs and outputs. It was proposed by the Swedish economist Knut Wicksell, who lived from 1851–1926, and tested by Charles Cobb and Paul Douglas in 1928. The Cobb-Douglas production function is a production function in the long run. In 1928, Charles Cobb and Paul Douglas published a study in which they modeled the growth of the

American economy from 1899–1922. They considered a simplified view of the economy in which the amount of labor and capital invested determines production output. Although many other factors influence economic performance, their model has proven remarkably accurate. The Cobb-Douglas production function is of the form (Cobb & Douglas, 1928; Hušek, 2007):

$$Q(L, K) = AK^{\alpha}L^{\beta}, \tag{1}$$

where

Q is the total output,

L is the labor input,

K is the capital input,

A is the technology level,

α is the elasticity of production relative to labor input,

β is the elasticity of production concerning capital input,

A, α, β are positive constants.

2.3. Method of Least Squares

One of the most widely used methods of estimating the production function is the least squares method, in which the function that leads to the smallest sum of squares of the deviations of the observed values of the dependent variable from the theoretical values calculated from the derived point estimation function is considered the most appropriate. The least squares method is a mathematical-statistical method and is particularly suitable for processing data obtained by measurement. It can also be used to find the Cobb-Douglas production function from the input data. First, we need to find a linear relationship between the unknown parameters. We take the natural logarithm of both sides from formula (1) to do this.

$$ln(Q) = ln(A) + \alpha \, ln(K) + \beta \, ln(L) \tag{2}$$

For the equation to make sense, the values of K, L, and Q must be positive, which always satisfies (we cannot have a negative number of workers, machines, and production must always be equal to zero). If we introduce the substitution

$$a = ln(A), x = ln(K), y = ln(L), z = ln(Q)$$

then the Cobb-Douglas production function can be rewritten as a linear economic metric model

$$z = a + \alpha x + \beta y, \tag{3}$$

Now, we will use the least squares method (OLS) to find suitable values of a, α, β. The essence of the least squares method is to determine the appropriate observation function y given the known observation matrix X to obtain the best estimates of the model's unknown parameters. If we limit ourselves to linear transformations y, then for a point linear estimation function or statistic, we can write b = Ay, where b is the column vector of the estimation of a, α, β, and A is a k × x matrix. More in (Šubrt, 2011).

After de-logarithming and substituting into the Cobb-Douglas production function, we get its resulting mathematical form for the given subject.

2.3. Coefficient of Determination

The coefficient of determination, commonly referred to as R^2 is a measure of the quality of a regression model in mathematical statistics, which in its basic form expresses what proportion of the variability of the dependent variable the model explains. The coefficient of determination can take on a maximum value of 1 (or expressed as a percentage of 100%), which means a perfect prediction of the values of the dependent variable. Conversely, a value of 0 (or 0%) means that the model does not provide any information for the knowledge of the dependent variable; it is completely useless. The coefficient of determination of a linear regression model is usually defined as one minus the quotient of the error variance (i.e., the differences between the model's predictions and the true values of the independent variable) and the variance of the independent variable (Salh, 2015; Yin, 2001).

3. Analysis and Results

3.1. Data Description

We obtained data for the manufacturing industry from the Ministry of Industry and Trade website (Ministerstvo průmyslu a obchodu České republiky, 2024); we obtained the main macroeconomic indicators from the website of the Czech Statistical Office (Český statistický úřad, 2024).

For the purposes of the Cobb-Douglas production function and Least Squares processing, we selected the following economic indicators: labour costs, investments, and EBIT. Due to data availability, we examined the development in the years 2008-2021; see Table 1.

Table 1. Labour costs, investments, and EBIT in 2008-2021

Year	Labour costs	Investments	EBIT
2008	315,710,942,000	225,851,380,000	188,386,692,000
2009	283,926,078,000	148,303,544,000	132,525,605,000
2010	286,905,981,000	142,894,670,000	204,227,236,000
2011	303,852,425,000	161,348,607,000	215,494,865,000
2012	313,559,542,000	177,572,810,000	216,890,602,000
2013	314,012,504,000	183,179,062,000	226,601,621,000
2014	328,840,762,000	208,429,860,000	302,690,252,000
2015	349,111,463,000	220,053,605,000	329,430,302,000
2016	373,513,341,000	215,652,485,000	314,898,375,000
2017	407,734,253,000	242,651,396,000	328,429,987,000
2018	443,078,891,000	281,135,918,000	311,888,110,000
2019	465,277,486,000	267,838,873,000	305,919,835,000
2020	456,103,533,000	233,466,350,000	239,114,992,000
2021	478,943,460,000	243,643,490,000	347,579,776,000

In the following Table 2, basic statistical characteristics are calculated for these selected indicators. From Table 2 can be seen that the smallest standard deviation can be observed for investments.

Table 2. Basic statistical characteristics for the investigated variables

Year	Labour costs	Investments	EBIT
count	14	14	14
mean	365,755,047,214.28	210,858,717,857.14	261,719,875,000.00
std	70,695,142,142.82	42,947,353,035.16	66,012,168,414.20
min	283,926,078,000.00	142,894,670,000.00	132,525,605,000.00
25%	313,672,782,500.00	178,974,373,000.00	215,843,799,250.00
50%	338,976,112,500.00	217,853,045,000.00	270,902,622,000.00
75%	434,242,731,500.00	240,355,134,500.00	314,145,808,750.00
max	478,943,460,000.00	281,135,918,000.00	347,579,776,000.00

The development is illustrated in the following graph (Figure 1). From the graph, you can see the decrease of the investigated quantities in 2020 due to the Covid-19 pandemic. The biggest drop in 2020 can be seen in EBIT.
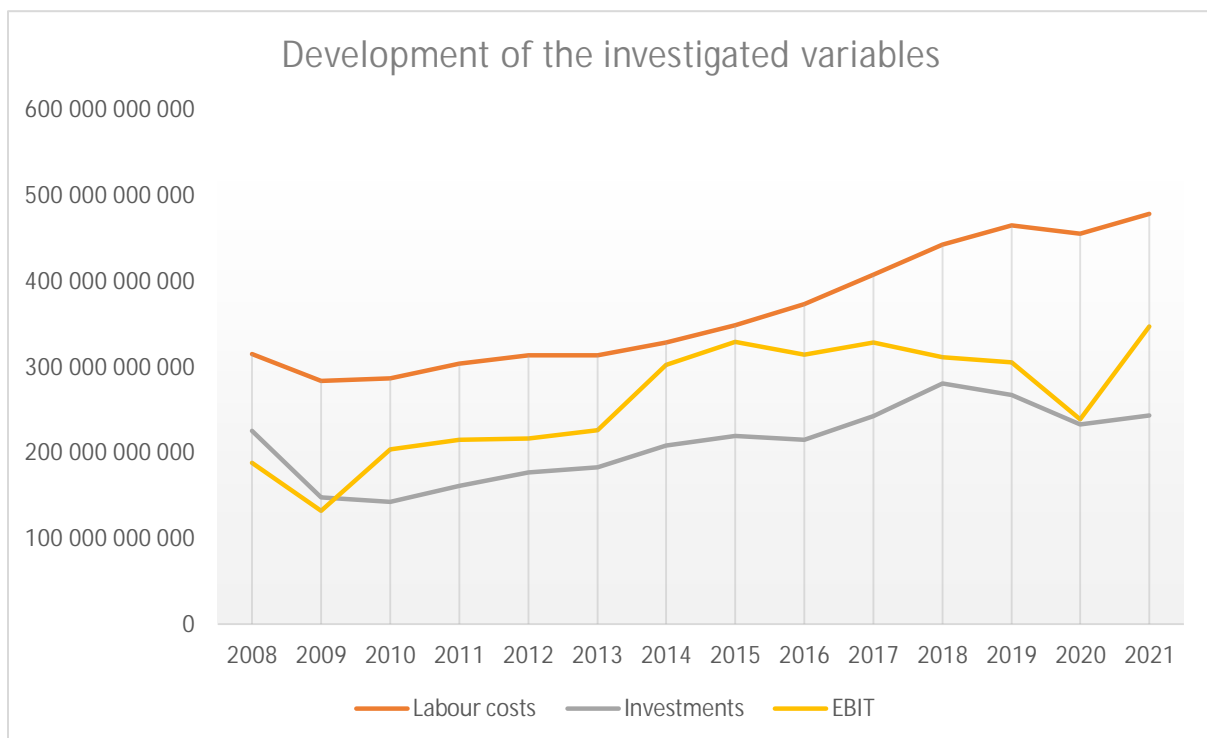
Figure 1. Development of investigated variables in 2008-2021

3.2. Correlation Analysis

From the following results of the correlation analysis, it can be seen that the investigated quantities are highly interconnected, which is not harmful for use in the Cobb-Douglas production function, since a relationship between the given quantities is assumed (see Table 3).

Table 3. Correlation analysis for the investigated variables

	Labour costs	Investments	EBIT
Labour costs	1.00000	0.86467	0.69759
Investments	0.86467	1.00000	0.72959
EBIT	0.69759	0.72959	1.00000

The degree of correlation is illustrated in the following graph (see Figure 2).

Figure 2. Correlation analysis for the investigated variables

3.3. Least Squares Method

Using the least squares method, applied to the Cobb-Douglas production function, we got the following elasticities (see Table 4):

Table 4. Results of elasticity coefficients computed using OLS method.

	Elasticity
α = elasticity for labour costs	0.35415402846865335
β = elasticity for investments	0.6461906128892037

3.4. Results for Cobb-Douglas Production Function

The following figures show the results of the Cobb-Douglas function. The first image Figure 3 below shows the surface for the natural logarithm, where the exact fit of the input points can be seen.

After de-logarithming and substituting into the Cobb-Douglas production function, we get its resulting mathematical form for the given subject. Figure 4 shows the surface after de-logarithming. Since many points are further away from the calculated surface, a smaller determination index can be expected for a given model.

3.5. Index of Determination for the Manufacturing Industry

For the created Cobb-Douglas production function model, we calculated the determination index:

$$R^2 = 0.548907753885556$$

Since this index is not very high, we wanted to find out which industries contribute the most to this result. Therefore, in the following section, we calculated the Cobb-Douglas production function for all sectors of the manufacturing industry and compared the values.
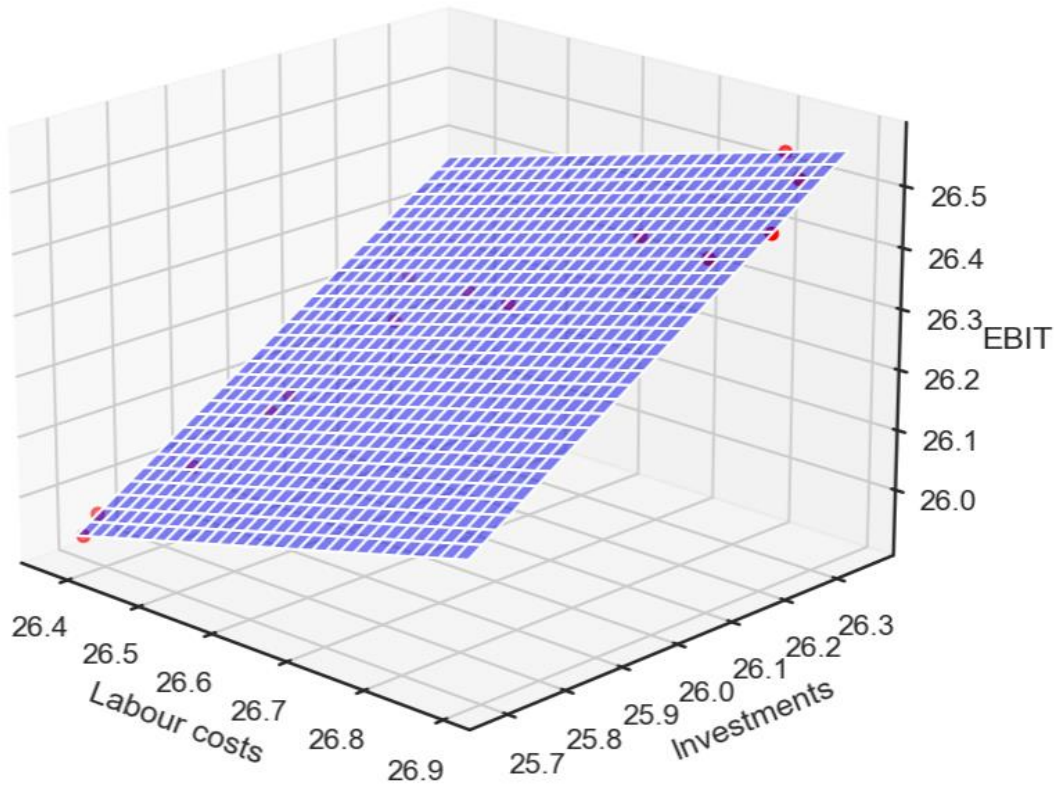
Figure 3. Results of the Cobb-Douglas function – logarithmic
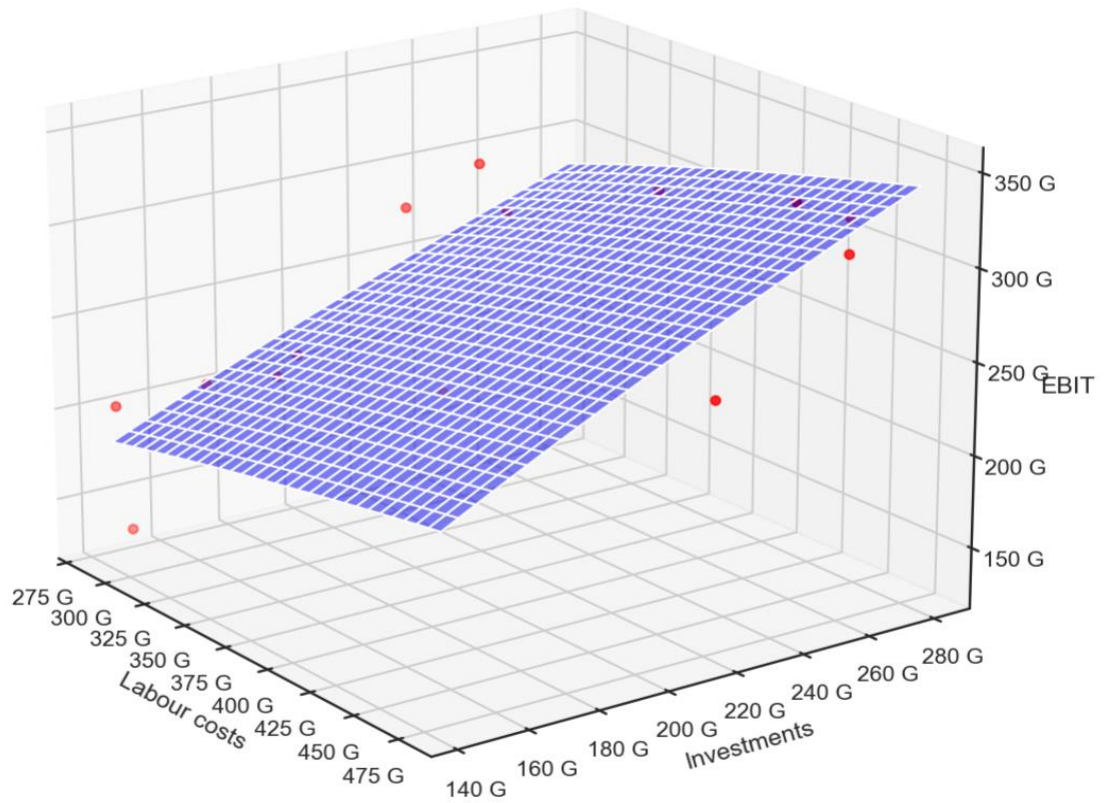
Figure 4. Results of the Cobb-Douglas function – final

3.6. Results for Individual Sectors of the Manufacturing Industry

The following Table 5 shows the results for individual sectors of the manufacturing industry, sorted by the coefficient of determination.

Table 5. Results for individual sectors of the manufacturing industry

	α	β	R^2
Manufacture of metal structures and fabricated metal products, except machinery and equipment	0.81	0.2	0.82
Other manufacturing	0.14	0.84	0.78
Production of other non-metallic mineral products	0.17	0.82	0.75
Manufacture of paper and paper products	0.09	0.9	0.55
Production of beverages	0.37	0.65	0.54
Manufacture of food products	0.33	0.64	0.52
Wood processing, manufacture of wooden, cork, wicker, and straw products, except furniture	0.69	0.32	0.43
Furniture production	-0.12	1.06	0.38
Printing and reproduction of recorded media	0.35	0.64	0.28
Manufacture of motor vehicles (except motorcycles), trailers and semi-trailers	0.68	0.31	0.25
Production of chemical substances and chemical preparations	0.49	0.52	0.21
Manufacture of basic pharmaceutical products and pharmaceutical preparations	-0.14	1.14	0.21
Manufacture of leather and related products	0.28	0.65	0.05
Production of textiles	0.22	0.74	-0.01
Production of rubber and plastic products	0.13	0.87	-0.01
Production of electrical equipment	-0.72	1.65	-0.25
Manufacture of machinery and equipment	0.62	0.37	-0.49
Production of other means of transport and equipment	-0.25	1.21	-0.85

Following sectors couldn't be computed caused by the negative EBIT value, which arose due to the inclusion of the period during the Covid-19 pandemic:

- Manufacture of clothing,
- Manufacture of basic metals, metallurgical processing of metals; foundry,
- Manufacture of computers, electronic and optical instruments and equipment.

For individual sectors, the highest value of the coefficient of determination came out for Manufacture of metal structures and fabricated metal products, except machinery and equipment, on the contrary, for many sectors this value came out very low. Which was caused by the drop in the investigated quantities around 2020.

4. Discussion

Much research points to the importance of literature that suggests doubts about the use of the Cobb-Douglas production function. The authors (Gechert et al., 2022) argue that after accounting for publication bias and model uncertainty, the true value of the elasticity of substitution decreases even more, highlighting the need for a critical approach to research methods. The accuracy of the central estimate of the elasticity of substitution is questioned, especially given possible limitations and dependence on available data. Further research is

suggested that would deal with more precise methods and include other determining factors. Overall, this discussion provides context for the study's results and suggests the need for further research on production functions and elasticity of substitution in economic models. Another research (Hašková et al., 2021) that compared the sector of knowledge-intensive services with the production function of the processing sector, which represents a key source of gross domestic product in the Czech Republic in the years 1995-2018. The results of this research show that even though manufacturing is one of the industries heavily dependent on physical capital, changing the capital to worker ratio in this industry has the biggest impact on output.

Other authors (Hájková & Hurník, 2007) point out that the Cobb-Douglas production function is used to analyze performance from the point of view of supply and to measure the country's production potential. However, this functional form assumes a constant share of labor in output, which may be too restrictive for a converging country. In the period 1995-2005, the authors (Hájková & Hurník, 2007) do not observe a significant difference between the calculation of the supply side of the Czech economy using the Cobb-Douglas production function and a more general production function, although the share of labor in the Czech Republic gradually increased.

The study (Husain, 2016) found that the study found that the coefficients for K and L are 0.49 and 0.51 for the entire manufacturing sector in Bangladesh, which means that labor is more productive than capital. Also, the estimated results (Zakir Hossain & Said Al-Amri, 2010) indicate that the manufacturing industry of Oman generally indicates a case of increasing returns to scale. Of the nine industries, seven show increasing returns to scale and only the remaining two show decreasing returns to scale between 1994-2007.

Our study also confirmed a higher coefficient for K (0.65) compared to the coefficient for L (0.35), which is consistent with the study mentioned above.

5. Conclusions

The aim of the article was to create a Cobb-Douglas production function for the manufacturing industry, both for the entire industry and for individual sectors. The compiled model for the entire manufacturing industry gave higher coefficient for K (0.65) compared to the coefficient for L (0.35), but the results for individual sectors were very varied.

Our study found that the coefficients for K and L are 0.65 and 0.35 for the entire manufacturing industry, which means that labor is more productive than capital.

In conclusion, it can be stated that Industry 4.0 represents an important factor in the substitution of labor by capital. This new industrial paradigm includes significant advances in automation, digitization, and the Industrial Internet of Things, which enable more efficient use of capital investment and reduce the need for human labor in some production and service processes. In this way, Industry 4.0 can contribute to increasing the productivity and competitiveness of the economy, but at the same time it can also have an impact on the labor market and require the adaptation of the workforce to new technologies and skills. It is therefore crucial to examine the impact of Industry 4.0 on the substitution of labor by capital and to prepare strategies and policies to successfully adapt to these changes in the industrial and work environment.

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Systematic Review of Current Risk Management Methods in Cybersecurity for Healthcare

Marie SOUKUPOVÁ* and Radek DOSKOČIL

Brno University of Technology, Brno, Czech Republic; Marie.Soukupova1@vut.cz; Radek.Doskocil@vut.cz

* Corresponding author: Marie.Soukupova1@vut.cz

Abstract: Presented systematic review is analyzing cyber risk management, more specifically economic aspect of the measures resulting from the risk analysis, through search of Web of Science and Scopus databases. The article questions the current scientific knowledge in the field of applicability of quantitative methods on measuring of the negative impact of successful cyberattacks. The purpose of the article is to define how these shall be improved for real application in the environment of healthcare, being specific not only by operating with sensitive patient data, but also by the urgency with which system malfunctions must be dealt with in order to prevent threatening the health and lives of patients (the fact that is providing the attacker with a unique position of privilege). While it is apparently necessary to invest more resources into the cybersecurity in healthcare, it is at the same time essential to ensure that these measures are profitable and the resources for them are spent economically. While cost of human life cannot easily be quantified, it is now time to search for methods on how to define an appropriate cybersecurity investment as opposed to the costs of a potential cyberattack.

1. Introduction

Cyberattacks on hospitals are something that one can come across very often these days. With increasing number of attacks, followed by increase of costs for ransom and/or repairs and decrease of availability of health services, the question of how these situations can be prevented naturally comes to mind. The causes of these situations (meaning specific examples of the lack of cybersecurity measures in the current healthcare) together with the possible methods of prevention (meaning the risk management approaches) will be discussed in this article.

The aim of this paper is to assess whether the level of scientific knowledge in the field of economic optimization of measures in the cyber risk management process in healthcare is sufficient and whether the current methods developed for measuring cyber risks are useful. The basic condition of the cyber risk management process indicates that the costs of security measures adopted in order to prevent cyberattacks shall be proportional to the amount of damage done in case of a successful cyberattack (ENISA, 2012). Thus, analyzing the economical aspect of security measures and especially the methods used to quantify it is the aim of this article.

The topic of the article concerns multiple scientific fields consisting of risk management on one side, and cybersecurity in healthcare on the other. While cybersecurity is an urgent and current topic among organizations around the world, one cannot only understand it from the perspective of technical and technological improvements, but must also always consider the costs of the measures. That is where risk management and its methods step in. Vice versa, cybersecurity plays an indispensable role in risk management, cyberattacks being often defined as the most serious and at the same time probable risks known to organizations. The most common cost of cyberbreaches in healthcare does not concern the purchase of new hardware, but the disruption of operations which means cutting the hospital off its funding from the health insurance companies which are financing the treatments (Lee, 2021).

1.1. Cybersecurity in Healthcare

Quite a few specifics of the field of cybersecurity can be found, among all else seeing that it is not something that organizations would proudly proclaim. For obvious reasons, if the level of security is low and proven by recent cyberbreach, the organization will have no desire to publicly talk about it, but even if the level of security is considered high in an organization, it is advised not to be very specific especially about its vulnerabilities. This fact makes research on the topic complicated. As well as digitalization, the cybercrime has also been rising exponentially in the course of the past few years. With the widening of the cyberspace in the recent years, frequent introduction of new technologies, the quantity of devices in a network, with wireless ones playing a major role, it has become easier to threaten organizations.

The state of cybersecurity in healthcare is inadequate to the state of security in other organizations, although interest in this topic from the side of senior management of healthcare facilities has changed considerably in the past few years as severe (especially ransomware) attacks on hospitals have been successful and gravely damaging (Pears & Konstantinidis, 2021). Nevertheless, cybersecurity, not being the primary service that the medical sector focuses on, still gets less attention and funding than necessary (Vukotich, 2023).

Moreover, what some senior managers do not realize is that cybersecurity does not only affect the IT department, but the entire patient care. As a matter of fact, close attention of the management should be paid to every aspect of the system that it is overlooking, from the perspective of its vulnerabilities to its defense mechanisms. The problem with rising investments in cybersecurity is the lacking data-driven strategy (Rothrock et al., 2017). Indeed fear, rather than a clear vision, should certainly not be the primary reason for cybersecurity investments. Additionally, it is necessary for the management to own responsibility for cybersecurity policies that it should ratify and comply with (Abraham et al., 2019).

It is no wonder that without constructive guidance from the authorities and with the shortage of cybersecurity specialists on the labor market, the facilities are uncertain about the security decisions and purchases that they should convey. As a consequence, most facilities lack cybersecurity strategies and since public spendings are being cut due to government's efforts for savings in almost all sectors (*[Czech] Government approved the state budget for 2024, decided to purchase F-35 supersonic aircraft and took another step to strengthen energy security*, 2023), cybersecurity budgets of hospitals can also be expected to decrease in the current calendar year.

Furthermore, the specific vulnerability of the healthcare sector is caused by the sensitive patient data that it operates with. Considering that sensitive data is even more valued by hackers than the data in banking or retail sectors (Symantec, 2017) puts extra stress on security in this industry. Henceforth, the human factor continues to prove as the weakest point of a security system in any organization (Lord, 2018), which, in case of healthcare, is even amplified by the notorious overwork of staff (Branley-Bell et al., 2021).

1.2. Devices and Networks in Healthcare

Although healthcare facilities usually do not operate with Internet of Things (IoT) devices since their technologies are more outdated and therefore, they do not face the severe threats of distributed denial-of-service (DDoS) attacks through IoT, they still face many problems concerning their networks. The problems are, of course, caused by the outdated technologies themselves together with a lack of surveillance (SCADA) systems, resulting in the fact that the administrators often do not operate with an up-to-date overview of the networks that it is their responsibility to monitor. In some sense, one can understand medical facilities as underdeveloped and/or family businesses in terms of their level of cybersecurity, main difference between the two categories being the size of the actual organization where hospitals ensure a wide range of processes varying from healthcare through catering to administration.

However, the current security concerns consist not only of staff and established technological measures (such as firewalls, antivirus or encryption) since these are not sufficient anymore (Branley-Bell et al., 2021), but also of increasingly common wearable devices, especially those connected to the cloud. These are a version of IoT that is beginning to be used in healthcare. As with technological innovations in general, pressing focus of developers on delivering the solutions first to market pushes product security to the sidelines (Mills et al., 2016).

Wearable devices are unique in many ways. First of all, they can not only be compromised in the sense of a data breach, but they also have the potential to physically hurt the patient wearing them (Mills et al., 2016), being in direct contact with their bodies (Mills et al., 2016). Although wearables are not the reality of the majority of hospitals today, they are definitely the long-term goal of healthcare (since they provide the patients with additional possibility of mobility during the recovery or monitoring phase of treatment) which is why it is necessary to take their vulnerabilities into consideration, especially since they can serve as means of compromising the entire network (Abraham et al., 2019).

1.3. Data and Regulations

Recent inevitable tightening of regulations concerning data protection (GDPR, 2018) has made it even more difficult for medical (as well as other) facilities to navigate themselves in the cybersecurity issues (Lee, 2021) which also increased requirements for already understaffed cybersecurity specialists. At the same time, more recommendations from the government in order to reduce the diversity of systems in each medical facility is advisable. A regulation named HIPAA (*Health Insurance Portability and Accountability Act of 1996*, 1996) which is in force in the USA can be used as a best practice, apparently taking

into consideration the differences that the healthcare systems in the USA and in European countries have.

Nowadays, data is the most valuable asset of organizations and therefore needs to be protected with special care. At the same time, in each organization, there are definitely various categories of data with different value. A breach of cafeteria menus will surely cost the healthcare facility less than the breach of results of screenings of patients including their social security numbers. That is why data within an organization shall be classified and protected based on its importance.

Healthcare sector, to a certain extent comparable to underdeveloped companies, can in some perspective benefit from its outdated technologies in use. Since there are increasing risks with new technologies (such as cloud services), the fact that those are not commonly used in this sector might be recognized as a risk reduction. However, this argument is false since often, the issue that the cloud services do not cover must still be replaced by another, often unsystematic and therefore even less secure solution.

For instance, oftentimes, the patient's data (such as screenings or scans) is not stored on a shared cloud storage, however multiple departments of the medical facility need to access it in order to provide the patient with further treatment. What they do is often either send the data physically (by printing each paper out or writing the conditions down by hand), or send it through personal, unsupervised online communication tools (such as WhatsApp or email) while neither of these solutions complies with any basic security rules. This is one of the processes that shall without a doubt be replaced by a robust controlled system so that the entire healthcare can share necessary sensitive information in a considerably safer way (Draper & Raymond, 2020).

The healthcare sector is now therefore facing a crucial question: how to fully digitalize its processes and data. The main risks of the digital transformation are apparent, most serious of them being unauthorized access to sensitive data. However, those risks (in limited sense) already occur in the current (insufficient) state of digitalization. What digitalization comes with is the solution for backups counting with high volumes of data being stored a safe, accessible cyberspace so that they are available even in case of crisis. Concluding that digitalization is certainly the way to go.

1.4. Risk Management

While all the aspects of cybersecurity mentioned above can be economically perceived as a cost, the question how to measure whether the cost is adequate to the risk and cost of potential damage done is still present. That is what the following chapters of the article are discussing.

2. Methodology

The systematic review includes synthesis of publications that had to fulfill predetermined eligibility criteria such as belong to the category "Economics and Business" within the Web of Science database, or be published in 2018 or more recently. The articles were searched within the Web of Science and Scopus databases using the keywords "cybersecurity" AND "hospitals" and "cyber risk management" AND "healthcare".
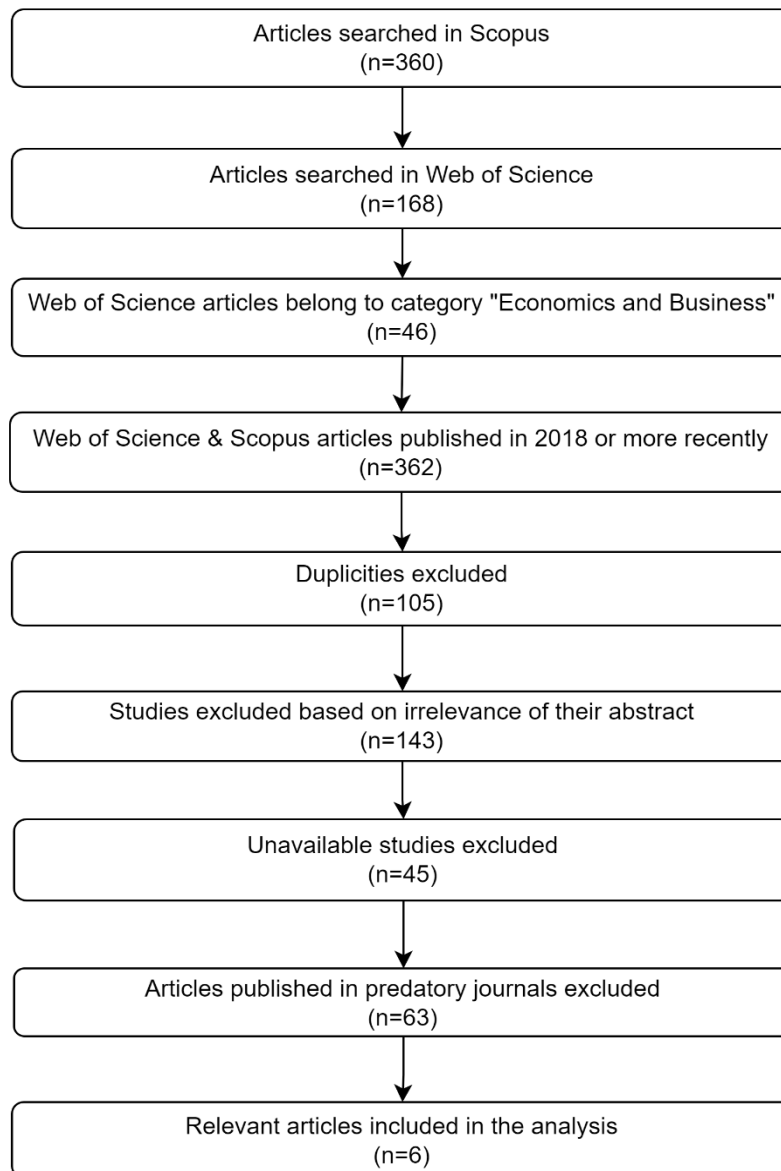
Figure 1: Flowchart of selection process of relevant articles

The findings were summarized and the subsequent outputs were analyzed. Implications were drawn based on them. Relevant studies were selected while excluding duplicities, irrelevant studies based on the content of their abstract, and unavailable studies were excluded as well as studies published in predatory journals. Useful references from suitable articles were used for further extension of the review.

Apart from the Web of Science and Scopus databases, a number of respectable websites of regulatory institutions was inspected (such as the official ENISA websites) for the purpose of this review.

3. Results

The review has concluded that there are quite a few approaches to cyber risk management. Some of them highlight the technological measures (Lockheed, 2009), some others point out the security of the entire supply chain (NIST, 2018) and other ones consider

Table 1: Bibliometric analysis of articles

Author	Title of Article	Title of Journal	Year of publication
Lee, In	Cybersecurity: Risk management framework and investment cost analysis	Business Horizons	2021
Abraham, Chon, Chatterjee, Dave, Sims, Ronald R.	Muddling through cybersecurity: Insights from the U.S. healthcare industry	Business Horizons	2019
Eaton, Tim V., Grenier, Jonathan H., Layman, David	Accounting and Cybersecurity Risk Management	Current Issues in Auditing	2019
Draper, Chris, Raymond, Anjanette H.	Building a risk model for data incidents: A guide to assist businesses in making ethical data decisions	Business Horizons	2019
Branley-Bell, Dawn, Coventry, Lynne, Sillence, Elizabeth	Promoting Cybersecurity Culture Change in Healthcare	The 14th Pervasive Technologies Related to Assistive Environments Conference	2021
Vukotich, George	Healthcare and Cybersecurity: Taking a Zero Trust Approach	Health Services Insights	2023

the human factor and consequent organizational measures as well. While all of that makes perfect sense, the problem in question is not only the definition of the measures themselves, as much as measuring of their costs and the costs of a potential cyberbreach, followed by a cost-benefit analysis.

Cybersecurity departments should thrive to quantify the impacts of risks as well as measures in order to justify investments into them (Lee, 2021) which is where the review found a blind spot. Not having access to accurate quantified data makes the work of cybersecurity managers in all sorts of organizations considerably more difficult especially in the aspect of negotiations on funding of cyber measures with the top management.

A few of the papers that were analyzed for the purpose of this review offer somewhat of a solution. The proposed cyber risk management framework designs four layers consisting of cyber ecosystem (outside of the organization itself), cyberinfrastructure (organization, employees, technologies), cyber risk assessment (designing the risk management together with investments needed) and cyber performance (consisting of the implementation, monitoring and continuous improvement of the cyber risk management) (Lee, 2021) that are to be governed by the cyber risk management.

Beyond doubt, the ecosystem layer (Lee, 2021) is a rather important one in case of healthcare, taking into account the different stakeholders in- and outside of its own field. Different healthcare facilities shall be able (under the condition of accessing only the data relevant for their own work – meaning the data of the patients that are in their care – not the data of all patients as is often the case) to exchange and discuss information related to the patient.

There are also ongoing debates about whether healthcare data should be used for other public service purposes (such as giving tax benefits to payers that prove that they attend check-ups). These debates are of course highly hypothetical at the moment since there are considerable problems accompanying the transfer of data within the healthcare sector itself, let alone its transfer beyond it. However, this only proves the importance of taking the surroundings of a single hospital into account when designing a cyber risk management framework in it.

In case of healthcare, the ecosystem consists mainly of its global supply chain management, patients, authorities, and the health insurance companies which are usually the main providers of income of the hospitals. Regarding cybersecurity area specifically, one shall also take into account the consulting specialists and the hackers.

Next on the list, the cyberinfrastructure layer, consisting of IT and non-IT staff as well as technologies within the organization (Lee, 2021), shall in opinion of the authors of this review be more specified by the public authorities, especially from the technological point of view. First of all, IT staff in hospitals could use guidelines to follow whereas minimalization of the diversity of networks in healthcare would help increase security overall. Cyber defense strategies followed by recurring trainings of all staff and possibly most importantly, a culture of positive cybersecurity behavior, are a part of this layer (Lee, 2021). Of course, keeping the technologies updated together with an overview of their vulnerabilities is essential here as well. Data also falls under this layer, nowadays being the primary target of the cyberattacks in healthcare and outside of it (Lee, 2021).

Cyber risk assessment layer is where this review can get inspired by standard risk management approaches, through risk identification, its quantification and cyber investment analysis (Lee, 2021). Identification of cyber risks can be done by learning from successful cyberattacks carried out on similar organizations (of course, the details of which the victims usually want to keep private because of the damage done to their corporate reputation). This is where experienced cybersecurity consulting specialists can prove very useful since they usually overlook a number of somewhat similar organizations. Once again, risk quantification is necessary for efficiency of investments into security (Chen et al., 2011).

While the method of cyber layers analyzed above, being one of the scarce number of methods published in scientific circles in recent years, describes the cyber risk management from all the different perspectives that need to be taken into consideration, it lacks a specific quantification method that could be used in the healthcare sector. The reason for quantification is as follows: security can never be established up to the point of elimination of all risks, both from technological point of view, where all risks can never be foreseen, and from the cost-benefit point of view, where cost of some measures exceeds the cost of damage done by certain risks.

Therefore, the realistic security approach must be to reduce the risk as long as implementation of measures against this risk has the same value as additional savings from possible incidents caused by it. Indeed, the process of estimating this value is where quantitative methods are needed, the issue with them being the lack of a standard that would

help determine the costs of security measures as well as costs of assets that are being protected by them (Bojanc & Jerman-Blažič, 2008).

Some of the variables that the papers analyzed for the purposes of this review mentioned as appropriate for quantification were namely frequencies of cyberattacks as well as financial losses resulting from each of them (Lee, 2021). Naturally, statistical methods (such as the probability density function) can also be used, although data from a SCADA monitoring system may be considerably more accurate.

Above all, the cost of a cyberbreach shall include fines, costs of lawyers and consultants hired to settle the problem and the value of data released (Lee, 2021), in case of healthcare extended by the ransom, relocation of patients to other sites, the cost of government penalties, recovering data and replacing equipment together with damage of reputation (Abraham et al., 2019).

While scientifically discussing different possible variables that could be included in a quantitative model, we cannot forget to take the reality in practice into account. It is possible that a given cybersecurity manager might not have access to all finance-related information in the organization. Before designing a feasible quantitative cyber risk model, it is therefore necessary to interview the professionals thoroughly.

The more precisely the risk is quantified, the easier it should be to advocate for the investment in the security measures through an elaborate cost-benefit analysis. Another approach mentioned in the analyzed papers describes comparing financial loss in case of a cyberbreach to the cyber investment cost, meaning the expenses for cybersecurity (Lee, 2021), suggesting a rather broad and unspecified variable.

4. Discussion

The review proved that there is a scientific gap in the sense of a quantitative cyber risk model that is currently missing. A number of scientific papers published in respectable journals was analyzed in order to confirm the need for a quantitative approach in the defined topic. A few of them indicated suitable variables to be included in such a quantitative model, though often without a proper consideration of whether the values of these variables are accessible to the cybersecurity experts within the organization which is applying the model in practice.

The apparent recommendation of the authors of this review concerns consulting an external cybersecurity specialist rather than assigning the cybersecurity role to a randomly selected member of the IT department. While learning from previous cyberattacks in similar facilities might be difficult due to their will to keep the details of the incidents private, cybersecurity experts are the ones able to share the lessons learned since they were often the ones witnessing it happen.

Clearly, there is space for future research in this area. One of the apparent directions includes cooperation among different departments of a healthcare facility. As described in more detail above, cyberattacks are not just the issue of one department since they effect the entire facility. Therefore, it is only logical to support cooperation of multiple parts of the facility to prevent them. What the authors of the review find especially potentially fruitful is the cooperation of cybersecurity managers and accountants who may be more competent to

quantify certain risks and costs associated with cyberattacks. Accountants, being experts in this field, shall offer their advisory and/or assurance capacities (Eaton et al., 2019). Only with specific and measurable impact of cyberattacks serving as proof can cybersecurity managers obtain better financial support for the protection of the networks from the side of the senior management. And that is why a quantitative cyber risk model is needed.

Furthermore, another research direction is at hand: during the design of the new model, authors must not forget to consult the cybersecurity experts in practice in order to include variables that they have access to and ensure the model's feasibility and usefulness. Thus, a set of interviews or questionnaires shall be conducted and analyzed for future steps of the research. The authors of the review would, among all else, like to statistically verify their assumption that cybersecurity staff in healthcare may benefit from advanced level of government support in the form of official recommendations regarding network resilience etc. A tool whose applicability in the field of cybersecurity in healthcare shall be examined from the point of view of scientific research is also the artificial intelligence. Many are discussing its security risks, but forgetting that it might be used as a part of security itself, especially in the context of shortage of staff and experts in cybersecurity, namely visible in healthcare.

The review defined a need for a feasible quantitative cyber risk model usable in healthcare which the practice is now lacking, resulting in low security overall. While defining the new model, not only shall the experts in practice be interviewed, but emphasis on continuous improvement shall be remembered since every model becomes less accurate with time passed, especially when it concerns the rapidly developing field of IT.

One does not need to be a cybersecurity expert to notice the fact that cyberattacks on hospitals have been rising in the past years. By being able to measure the costs and benefits of security as well as the costs of damage done, hospitals (as well as other organizations) will be able to make informed and strategic decisions concerning their security and their patients will be able to recover in a safe space. By building resilient networks supported by verified providers, the cyberattacks shall become less and less successful, eventually making healthcare sector unappealing for hackers to whom it will be hard to affect it and hospitals shall once again become the places where citizens in their greatest need will come with full trust in the institutions of healthcare as well as the state itself.

Conflict of interest: none.

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A Quantitative Picture of the Diversity of Technical Infrastructure in the Catchment Areas of Airports in Poland

Agata SURÓWKA

Rzeszow University of Technology, Rzeszow, Poland; agasur@prz.edu.pl

Abstract: Recent years have brought a very extensive discussion on the definition of regional competitiveness and factors influencing the improvement of the competitive position. The problem of competitiveness is being discussed more and more widely in research on the regional and local economy. Its main factors include technical infrastructure. The aim of the analysis was to verify the differences in its level in districts located in the area of influence of airports in Bydgoszcz, Poznań and Wrocław in the future. Recently, many publications have been published in which researchers make an effort to identify the differences in infrastructure in the regions of the European Union. In the European literature, the lack of articles examining it in the areas of overlapping airport isochrones is particularly acute. The author decided to fill this gap by conducting research, a fragment of which is included in the text, and which is a continuation of previously published research. The research and forecasting tool was the medium-term rate of change method. The forecasts were prepared for the years 2022-2023. The results obtained from the analysis allowed to draw detailed conclusions.

Keywords: regional development management; spatial management; forecasting; sustainable development; air transport; airport isochrones

JEL Classification: R11; O11

1. Introduction

The literature presents various definitions and concepts (see Surówka (2007) or Surówka (2009) or Polna (2017) or Maciulyte-Sniukiene et al. (2022) or Fourie (2006) or Klepacka – Dunajko (2017) or Kroszel (1997)). One of them defines it as a complex of public utility facilities necessary to ensure the proper functioning of the national economy and the life of the population, appropriately distributed in space, along with historically shaped internal and at the same time characteristic relations between the individual elements (Kupiec et al., 2005). According to another author, it is a set of devices, networks of buildings and systems that do not directly relate to the production of material goods, but are necessary for the implementation of the production process itself. It is undeniable that broadly understood infrastructure is one of the factors traditionally indicated in both development and competitiveness theories (Pomianek, 2020). Among a wide range of development factors, great importance is attached to infrastructural equipment, especially in territorial units characterized by a low level of socio-economic development. Infrastructure investments are

of fundamental importance for stimulating the economic strength of the region, as they constitute the basis for supporting various activities that will result in economic growth (Miłek, 2022). As some authors rightly point out, the level of infrastructure development may determine the attractiveness of a spatial unit, and thus constitute an important element of regional or local competitiveness, as well as determine opportunities or threats for further development. Investment in infrastructure is key to stimulating economic dynamics as it forms the basis for supporting various measures aimed at economic growth (Miłek, 2022). In their research, some authors analyze the relationship between infrastructure and entrepreneurship (see Audretsch et al., 2015). Technical infrastructure plays an important role in stimulating social and economic development (Chwastek et al., 2021). As mentioned, the literature on the subject provides many definitions of this concept. It is a popular statement that it should be understood as basic devices and institutions providing services necessary for the proper functioning of the economy and the life of society (Wawrzyniak, 2015). In one of the works, a very synthetic and general definition was given, according to which it is a set of technical devices for public use that are the product of people, appropriately organized into systems, the functional effects of which are important for the functioning of the economy and people's existence (Surówka, 2007). In addition to the diversity of infrastructure concepts, there is also a lack of uniform classification of this concept. It is most often divided into technical and social. The first of them are devices, industrial networks and related facilities that provide necessary and basic services for a specific spatial and economic entity in the field of energy, heat and water supply, sewage and waste disposal, transport, telecommunications, etc. (Surówka, 2007). On the other hand, institutions in the field of education and upbringing, dissemination of culture, health care, social welfare and housing, which serve to improve the general standard of living of residents, are called social infrastructure. The author defines this issue similarly, according to whom it should be understood as a set of public utility devices necessary primarily to ensure the proper functioning of the national economy and proper integration of individual systems of the socio-economic space. By some authors it is also called economic, technical-economic, production or economic (Surówka, 2007). The literature also quite often emphasizes the fact that while in the case of technical infrastructure there is agreement as to the scope of this concept, in the case of social infrastructure there is no unanimity. It must be stated with certainty that infrastructure is increasingly often associated as a source of competitive advantage. Without increasing the level of infrastructure development, it is impossible to achieve the appropriate level of development. Therefore, according to some authors (Sztando, 2004), infrastructure development should support the development of entrepreneurship.

In the own research presented in the practical part, several specific goals were set. One of them is an attempt to determine whether economic development processes in some regions have been and still are conducive to increasing the competitiveness of weaker areas or widening disproportions. During the research procedure, the following hypotheses were also formulated: Hypothesis 1:. Districts located in the areas of influence of the studied airports are characterized by dynamic changes in the diversification of infrastructure development, which translates into significant variability of positions in the rankings for selected features

characterizing them. Moreover, counties located in the areas of influence of overlapping isochrones occupy distant places in the rankings. Hypothesis 2: The values of features characterizing infrastructure are not subject to dynamic changes, which means that preparing forecasts of this phenomenon should be considered important. During the research, both hypotheses were verified and the goal was achieved.

2. Forecasting as a Research Tool

Forecasting is the rational and scientific prediction of the future. According to another definition, it is a rational, scientific prediction of future events, the result of which is a forecast. The forecasting process must be carefully planned and carefully carried out. In addition to the analyst, the recipient of the forecast should also participate in it. The recipient does not need to know forecasting methods; it is enough that the requirements regarding the shape and result are clearly formulated. The forecasting process consists of the following elements:

- Formulation of the forecasting task
- Formulation of prognostic premises
- Choosing a forecasting method
- Forecast construction
- Forecast verification

Forecasting uses information about these factors and their impact on the phenomenon under study. Forecasting examines the relationship between these factors and the phenomenon under study, as well as the formation in the past in order to draw conclusions about the future. Statistical and mathematical sciences are used for forecasting. The diversity of definitions is justified by the diversity of forecasting situations, goals and research methods. Forecasting supports decision-making processes and prepares other activities, this is the basic function – preparatory. The activating function of the forecast consists in stimulating actions conducive to the implementation of the forecast. The information function prepares people for upcoming changes and reduces fear of them. Many methods are used for forecasting. In the practical part, the medium-term rate of change method was used (Surówka, 2023). Forecasts using this method are made using the following formulas:

$$\overline{T_n} = (\overline{i_g} - 1) \cdot 100\%$$

(1)

where:

$$\overline{i_g} = \sqrt[n-1]{i_{n/n-1} \cdot i_{n-1/n-2} \cdot \ldots \cdot i_{2/1}}$$

(2)

Then, the forecast values are determined according to the formula:

$$K_n = K_0 (1+r)^n$$

(3)

K_n – forecast of the value of the feature in the period n

K_0 – value of the variable from the last research period

r – medium-term pace of change

n – number of periods

3. Dynamic and Prognostic Analysis of the Diversity of Technical Infrastructure in the Areas Affected by Airports in Poznań, Wrocław and Bydgoszcz

There are various criteria for separating the area of influence of air transport in the literature. One of them is the area of a circle with a radius of about 100 km in the center of which there is an airport. This method is quite often called isochronous and it was used in our own research.

In our own research, at the beginning, based on the literature, the names of districts located in the impact zones of the Bydgoszcz Szwederowo, Poznań - Ławica and Wrocław - Strachowice Airports were defined. The obtained results are presented in table 1.

Then, statistical material was collected for the features most often used to define technical infrastructure. Due to the fact that it should be considered from a multi-level and multi-aspect perspective. Moreover, as some authors rightly point out, infrastructure is most often presented as a set of devices and facilities that perform ancillary functions in relation to other spatial systems. Taking into account one element of infrastructure, it is not possible to assess the infrastructure due to significant differences in the spatial distribution of indicators (Kołodziejczyk, 2017). Taking the above into account, it was finally decided to define the examined category using nine measures that could, at least approximately, define the examined phenomenon. The choice of these measures was dictated by the availability of research material and based on previous research experience (Salamon et al., 2018), (Surówka, 2022). Ultimately, the examined category was defined using the following indicators:

X_9 - population using sewage treatment plants as a percentage of the total population (%)

X_8 - length of municipal and district public roads with paved surfaces (in km)

X_7 – length of public municipal and district roads with unpaved surfaces in km per 100 square kilometers of surface

X_6 – length of public municipal and district roads with hard surfaces in km per 100 square kilometers of area

X_5 - percentage of all apartments connected to the sewage system

X_4 – percentage of all apartments connected to the water supply network
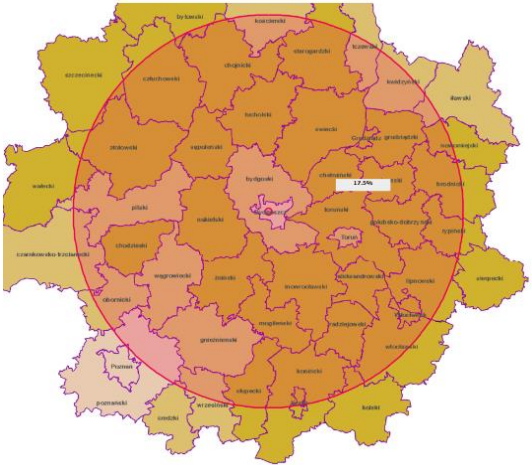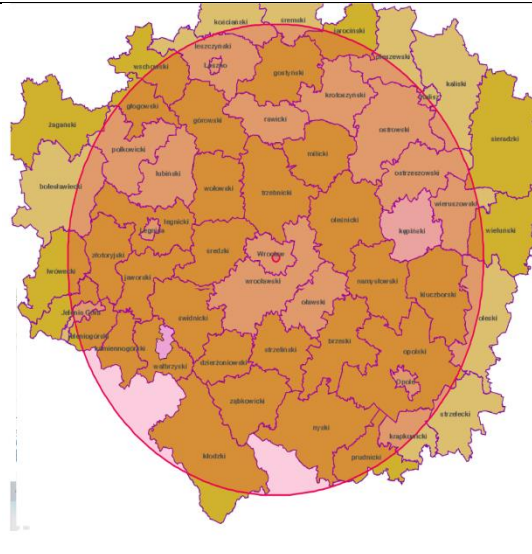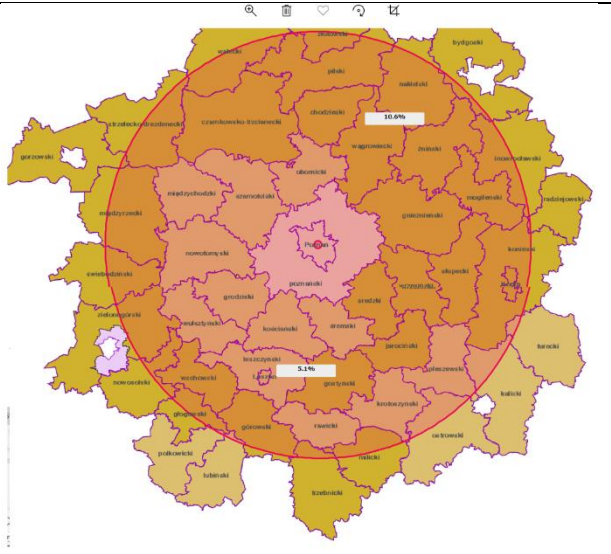
X_3 - length of the gas distribution network in km per 100 square kilometers of area

X_2 - length of the water distribution network in km per 100 square kilometers of area

X_1 - length of the sewage distribution network in km per 100 square kilometers of area

The next step to achieve the research goals was a detailed quantitative analysis of the obtained statistical information. Then forecasts were made. The medium-term rate of change method was chosen as the research tool. The forecast period covered the years 2022-2023. Forecasting is the prediction of phenomena and processes in the future based on scientific foundations. The author defines this issue similarly, according to whom forecasting is a scientific method of predicting how processes or events will develop in the future. They are most often used to minimize uncertainty about future events that will occur in the future. Such action provides information on the topic we are interested in, prompts us to make decisions related to the implementation of the prepared forecast and prepares us to take other

Table 1. Districts and cities with districts rights located within the area of influence of airports in Wrocław, Bydgoszcz and Poznań

Bydgoszcz Szweredowo Airport	Bydgoszcz Szweredowo Airport (districts and cities with district rights): bydgoski, toruński, Bydgoszcz, Toruń, brodnicki, chełmiński, golubsko-dobrzyński, grudziądzki, rypiński, wąbrzeski, Grudziądz (Gdańsk), aleksandrowski, lipnowski, radziejowski, włocławski, Włocławek, inowrocławski, mogileński (Poznań), nakielski (Poznań), żniński (Poznań), sępoleński, świecki, tucholski

Wrocław - Strachowice Airport	Poznań Ławica Airport

Wrocław – Strachowice Airport (districts and cities with district rights): wrocławski, Wrocław, Opole (Katowice), Leszno (Poznań), lubiński, leszczyński (Poznań), Legnica, jeleniogórski, śremski (Poznań), średzki (Poznań), oławski, ostrowski, trzebnicki, kościański (Poznań), ostrzeszowski, Jelenia Góra, świdnicki, kępiński, bolesławiecki, gostyński (Poznań), pleszewski (Poznań), oleśnicki, brzeski (Kraków, Rzeszów, Katowice) głogowski, milicki, polkowicki, namysłowski (Katowice), złotoryjski, wschowski (Poznań), jarociński (Poznań), ząbkowicki, legnicki, opolski (Rzeszów, Katowice), kluczborski (Katowice), rawicki (Poznań), krotoszyński (Poznań), krapkowicki, wołowski, dzierżoniowski, nyski (Katowice), wieruszowski (Katowice), strzeliński, jaworski, wałbrzyski, kłodzki, lwówecki, kamiennogórski, prudnicki (Katowice), górowski (Poznań)

Poznań Ławica Airport (districts and cities with district rights): górowski (Wrocław), mogileński (Bydgoszcz), nakielski (Bydgoszcz) , żniński (Bydgoszcz), międzyrzecki, sulęciński, wschowski (Wrocław), Zielona Góra, chodzieski, czarnkowsko-trzcianecki (Szczecin), gnieźnieński, gostyński (Wrocław), grodziski (Warszawa), jarociński (Wrocław), koniński, kościański (Wrocław), krotoszyński (Wrocław), leszczyński (Wrocław), międzychodzki, nowotomyski, obornicki, pilski, pleszewski (Wrocław), poznański, rawicki (Wrocław), słupecki, szamotulski, średzki (Wrocław), śremski (Wrocław), wągrowiecki, wolsztyński, wrzesiński, Konin, Leszno (Wrocław), Poznań, choszczeński (Szczecin)

actions. The main goal of the presented part of the study is to identify the degree of diversification of infrastructural development of counties located in the zones of influence of selected airports in Poland in the forecast period. The main reason for undertaking the research was the poor interest of researchers in the discussed issues. The results from the second stage (forecast values) for the first three indicators are presented in tables 2-4. In Table 2, information for four counties located in the catchment areas of at least two airports is bold. The tables also contain information about the positions occupied in the rankings by the surveyed units in 2023.

Table 2. Forecast of the length of the distribution network in counties located in the impact areas of the Bydgoszcz Szweredowo Airport (2021-2022)

	2021	2022	2023		2021	2022	2023		2021	2022	2023	
	Variable X_1			R	Variable X_2			R	Variable X_3			R
Aleksandrowski	59.9	61.99	64.15	6	189.8	190.61	191.41	5	21.2	22.54	23.97	9
Brodnicki	48.0	48.68	49.37	11	145.0	145.94	146.89	13	13.1	15.43	18.18	13
Bydgoski	50.0	51.92	53.92	7	125.2	127.12	129.06	16	45.8	51.37	57.62	5
Chełmski	48.1	49.01	49.95	8	147.1	147.72	148.35	11	21.3	23.72	26.41	8
Golubsko-dobrzyński	30.7	31.10	31.51	19	178.7	179.09	179.49	6	6.0	6.67	7.42	21
Grudziącki	32.2	33.41	34.67	15	158.8	160.38	161.97	9	16.6	18.62	20.89	11
Inowrocławski	48.5	49.14	49.79	9	126.5	127.69	128.89	17	27.8	29.44	31.18	6
Lipnowski	15.3	15.95	16.64	23	148.5	148.93	149.36	10	0.8	0.86	0.93	23
Radziejowski	21.6	22.11	22.63	22	169.1	170.02	170.95	7	4.8	5.55	6.42	22
Rypiński	34.5	35.82	37.19	14	146.2	146.87	147.54	12	7.6	9.16	11.05	19
Sępoleński	29.7	30.87	32.08	18	87.0	87.68	88.37	22	9.4	9.98	10.59	20
Świecki	47.6	48.49	49.39	10	107.6	108.36	109.12	19	12.9	14.07	15.35	16
Toruński	61.1	63.42	65.82	5	138.3	139.95	141.62	15	23.2	25.77	28.63	7
Tucholski	44.5	45.21	45.93	13	80.6	80.78	80.96	23	14.4	15.65	17.01	14
Wąbrzeski	45.2	45.58	45.97	12	162.0	162.72	163.43	8	15.9	17.62	19.53	12
Włocławski	27.6	29.13	30.74	20	144.1	145.33	146.57	14	10.9	11.27	11.64	18
Bydgoszcz	408.5	411.82	415.17	2	365.7	367.99	370.30	2	400.2	406.74	413.38	1
Toruń	596.3	622.75	650.37	1	352.9	358.77	364.74	3	379.5	383.00	386.53	3
Włocławek	307.8	317.14	326.76	4	252.1	248.57	245.09	4	254.9	256.83	258.77	4
Mogieliński	**33.6**	**33.91**	**34.23**	**16**	**106.7**	**107.03**	**107.36**	**20**	**13.1**	**13.82**	**14.58**	17
Nakielski	**25.0**	**25.63**	**26.27**	**21**	**86.6**	**88.01**	**89.44**	**21**	**17.5**	**19.26**	**21.19**	10
Żniński	**32.7**	**32.92**	**33.14**	**17**	**108.0**	**109.01**	**110.03**	**18**	**13.8**	**14.95**	**16.20**	15
Grudziądz	361.1	366.27	371.52	**3**	379.3	385.55	391.91	**1**	385.0	392.24	399.61	2

Analyzing the information contained in Table 2, we notice that the length of the distribution network in the counties located in the catchment area of the Bydgoszcz Szweredowo Airport varies. The analyzed set of variables is characterized by varying variability. The clear leader in terms of the length of the sewage distribution network is Toruń, the water distribution network is Grudziądz and the gas distribution network is Bydgoszcz. This allows us to claim that the highest places in the ranking are occupied by district cities. The catchment area of the Bydgoszcz airport also includes the mogieliński and żniński districts, which are also located in the isochrone area of the second Poznań Ławica Airport covered by the study. In terms of the second and third features, żniński districts is more distant in the area of influence of this port. The situation is definitely the worst (in the

Table 3. Forecast of the length of the distribution network in counties located in the impact area of the Wrocław - Strachowice Airport (2021-2023)

	2021	2022	2023		2021	2022	2023		2021	2022	2023	
	Variable X_1			R	Variable X_2			R	Variable X_3			R
Bolesławiecki	71.0	73.61	76.32	17	59.1	60.01	60.94	40	21.2	22.05	22.93	33
Dzierżoniowski	58.0	58.49	58.98	23	75.5	76.33	77.18	31	62.7	63.91	65.14	10
Głogowski	88.6	91.62	94.75	13	99.9	100.99	102.09	17	58.3	61.66	65.22	9
Górowski	11.1	11.45	11.81	47	60.2	61.10	62.01	39	12.4	12.54	12.68	45
Jaworski	59.9	61.67	63.49	21	61.7	62.54	63.40	38	19.3	19.51	19.72	35
Kamiennogórski	47.3	48.10	48.91	27	76.0	76.98	77.98	30	33.8	36.75	39.97	23
Kłodzki	36.9	38.17	39.49	35	54.2	55.28	56.38	42	32.0	33.50	35.07	28
Legnicki	83.4	86.22	89.14	14	77.6	77.92	78.24	29	38.9	41.44	44.15	21
Lubiński	98.1	100.57	103.11	10	77.8	79.04	80.29	28	62.5	63.75	65.02	11
Lwówecki	33.5	34.17	34.86	39	50.2	50.76	51.33	46	9.5	9.72	9.95	46
Milicki	41.8	43.81	45.91	31	55.2	55.75	56.30	43	15.8	16.25	16.70	41
Oleśnicki	35.8	36.88	37.99	36	89.6	90.77	91.96	21	34.7	36.02	37.39	25
Oławski	101.2	108.36	116.03	6	104.4	109.88	115.64	11	52.8	57.53	62.68	13
Polkowicki	63.2	64.75	66.34	19	70.3	71.34	72.39	33	42.8	44.11	45.47	20
Strzeliński	35.7	37.75	39.92	34	58.4	58.67	58.95	41	12.3	13.23	14.22	44
Świdnicki	92.9	100.62	108.98	7	107.7	108.62	109.54	14	50.1	51.37	52.67	15
Trzebnicki	26.0	27.46	29.00	45	81.4	82.67	83.96	25	34.4	35.85	37.37	26
Wałbrzyski	48.3	47.53	46.78	29	69.7	67.01	64.43	37	44.8	42.09	39.55	24
Wołowski	39.9	40.88	41.88	33	49.8	50.41	51.04	47	17.2	18.37	19.63	36
Wrocławski	98.3	102.49	106.86	8	144.5	148.69	153.01	7	81.7	89.03	97.02	7
Ząbkowicki	28.1	29.04	30.01	43	66.7	69.49	72.41	32	17.0	17.99	19.04	37
Złotoryjski	43.5	44.01	44.52	32	54.8	55.50	56.20	44	16.7	17.44	18.21	39
Jelenia Góra	265.2	271.84	278.64	5	337.4	341.57	345.79	5	276.1	285.87	295.99	4
Legnica	379.1	382.67	386.28	4	366.7	370.07	373.48	3	390.4	398.58	406.94	3
Wrocław	436.0	454.24	473.25	2	463.9	466.34	468.79	2	491.9	493.42	494.95	2
Wschowski	31.7	33.01	34.38	41	53.6	54.34	55.08	45	15.3	16.33	17.43	40
Wieruszowski	50.8	51.78	52.77	26	108.3	109.25	110.21	13	6.1	6.60	7.14	47
Brzeski	90.4	95.40	100.67	11	153.3	157.03	160.84	6	193.8	196.55	199.34	6
Ostrowski	19.6	20.55	21.55	46	86.7	87.51	88.34	22	18.3	19.61	21.02	34
Kluczborski	28.6	30.02	31.51	42	64.4	64.66	64.92	35	17.0	17.86	18.76	38
Krapkowicki	89.4	94.17	99.19	12	91.6	92.00	92.40	20	43.6	45.19	46.83	19
Namysłowski	29.3	32.18	35.34	38	64.6	65.33	66.06	34	12.8	13.62	14.50	42
Nyski	48.4	50.57	52.84	25	81.5	83.59	85.73	24	29.8	30.98	32.21	30
Opolski	80.1	83.83	87.73	15	87.4	87.48	87.56	23	26.1	29.27	32.83	29
Prudnicki	27.8	28.58	29.37	44	64.1	64.50	64.90	36	14.0	14.20	14.41	43
Opole	376.7	387.10	397.79	3	348.7	354.99	361.39	4	277.9	277.47	277.04	5
Gostyński	45.8	47.31	48.87	28	95.8	96.44	97.09	19	63.8	64.04	64.28	12
Jarociński	98.8	101.23	103.72	9	116.9	117.55	118.21	10	66.9	68.05	69.22	8
Kępiński	71.2	75.30	79.64	16	106.0	106.84	107.69	15	21.1	22.87	24.80	32
Kościański	62.8	65.76	68.86	18	99.9	100.50	101.09	18	57.2	58.94	60.73	14
Krotoszyński	34.6	35.55	36.53	37	114.3	114.38	114.46	12	44.6	45.97	47.37	18
Leszczyński	46.0	49.83	53.98	24	79.8	81.20	82.63	26	42.3	45.53	49.01	16
Ostrzeszowski	33.3	34.04	34.80	40	130.8	131.25	131.71	8	34.3	34.91	35.52	27
Pleszewski	40.0	42.95	46.11	30	118.6	120.19	121.80	9	26.7	27.63	28.60	31
Rawicki	60.3	62.13	64.01	20	81.7	82.09	82.48	27	47.1	47.88	48.68	17
Śremski	55.7	57.32	59.00	22	101.0	102.05	103.12	16	40.2	40.68	41.17	22
Leszno	660.4	666.35	672.35	1	500.0	504.64	509.33	1	679.1	683.64	688.20	1

area of influence of the Bydgoszcz Szwederowo Airport) in the following districts: lipnowski and tucholski. The development strategy of the lipnowski district contains information that the availability of network devices and universal access to the infrastructure of the area has a huge impact on decisions made regarding the location of both residential construction and projects related to the construction/expansion of industrial investments (Strategia Obszaru Rozwoju Społeczno – Gospodarczego Powiatu Lipnowskiego). Similar forecasts were made for the catchment area of Wrocław Strachowice Airport. The results are summarized in Table 3. Analyzing the information contained therein, we notice that most districts are characterized by an increase in the distribution network, the decline only concerns the włabrzyski districts. In the catchment area of Wrocław Starachowice Airport, Leszno is the clear leader. Wrocław is next in the ranking. The area of influence of this airport includes górowski and wschowski districts, which is also within the catchment area of Poznań Ławica Airport. In terms of the examined features, they occupy very distant positions. In terms of features X1 and X2 wieruszowski districts (also located in the catchment area of the Katowice Pyrzowice Airport) occupies much higher positions in the rankings in the catchment area of the examined ports. Kluczborski districts is also within the catchment area of the Katowice Pyrzowice Airport. Analyzing it against the background of other counties, it should be stated that it occupies higher positions in the ranking presented in Table 3. The district that compares most favorably to this area of influence is Opole. Analyzing the information contained in Table 3, it can also be concluded that there are more units in the zone of more than one airport compared to the area of influence of the Bydgoszcz-Szweredowo Airport. Moreover, districts located in the catchment area of more than one airport occupy distant positions (more than half) in the infrastructure development rankings.

Similar forecasts were prepared for districts located in the catchment area of Poznań Ławica Airport. The results are presented in Table 4. Analyzing the information contained in this table, one can notice a very large diversity of positions in the rankings in terms of the examined features. The highest position in the distribution network length forecast ranking is occupied by Leszno in the districts located in the influence zone of the Poznań Ławica Airport, and the lowest by the following districts: trzebnicki (variable X1), wschowski (variable X2) and górowski (variable X3). The best infrastructure development in terms of the examined features in the studied area is characterized by district cities (Leszno, Wrocław and Opole). Pleszewski districts is also a unit located in the catchment area of the Wroclaw Starachowice Airport. In terms of the examined features, the results are different in both studied areas.

4. Discussion and Conclusion

The topic of the work was issues related to the development of technical infrastructure in the catchment areas of airports in Poland. The aim was to identify spatial inequalities in infrastructure development in counties located in the impact zones of airports in Bydgoszcz, Wrocław and Poznań. During the research, a statistical assessment was made of the level of infrastructure development in counties located in the three studied isochrones. In the last

Table 4. Forecast of the length of the distribution network in counties located in the influence areas of the Poznań-Ławica Airport (2021-2023)

	2021	2022	2023		2021	2022	2023		2021	2022	2023	
	Variable X_1			R	Variable X_2			R	Variable X_3			R
Górowski	11.1	11.45	11.81	35	60.2	61.10	62.01	31	12.4	12.54	12.68	34
Średzki	55.1	57.82	60.68	11	72.0	72.99	73.99	28	26.8	28.76	30.86	21
Mogileński	33.6	33.91	34.23	27	106.7	107.03	107.36	14	13.1	13.82	14.58	32
Nakielski	25.0	25.63	26.27	30	86.6	88.01	89.44	23	17.5	19.26	21.19	24
Żniński	32.7	32.92	33.14	28	108.0	109.01	110.03	13	13.8	14.95	16.20	29
Międzyrzecki	26.3	27.38	28.51	29	27.1	27.33	27.57	35	14.0	14.05	14.09	33
Sulęciński	15.8	16.11	16.42	34	30.5	30.69	30.89	33	14.8	15.05	15.31	31
Wschowski	31.7	33.01	34.38	25	53.6	54.34	55.08	32	15.3	16.33	17.43	28
Zielona Góra	153.6	136.44	121.20	5	161.1	145.94	132.20	6	177.9	164.07	151.32	5
Grodziski	132.1	135.50	138.99	3	293.5	298.43	303.45	2	192.4	196.53	200.76	3
Chodzieski	57.3	58.62	59.96	12	88.5	89.16	89.82	22	34.3	35.12	35.97	20
Czarnkowsko – trzecianecki	19.3	19.80	20.32	33	63.0	64.09	65.20	29	7.2	7.51	7.84	35
Gnieźnieński	67.4	70.41	73.55	8	124.1	126.60	129.15	7	70.7	74.43	78.36	6
Gostyński	45.8	47.31	48.87	17	95.8	96.44	97.09	20	63.8	64.04	64.28	8
Jarociński	98.8	101.23	103.72	6	116.9	117.55	118.21	10	66.9	68.05	69.22	7
Koniński	43.9	46.34	48.91	16	155.0	155.89	156.79	5	13.3	14.45	15.70	30
Kościański	62.8	65.76	68.86	9	99.9	100.50	101.09	16	57.2	58.94	60.73	10
Krotoszyński	34.6	35.55	36.53	24	114.3	114.38	114.46	11	44.6	45.97	47.37	14
Leszczyński	46.0	49.83	53.98	14	79.8	81.20	82.63	25	42.3	45.53	49.01	12
Międzychodzki	24.9	25.32	25.75	31	60.1	61.25	62.42	30	17.3	18.35	19.46	26
Nowotomyski	33.1	35.12	37.27	22	91.5	92.80	94.12	21	50.8	53.10	55.51	11
Obornicki	44.6	46.18	47.82	18	98.0	99.12	100.25	18	34.9	35.78	36.68	19
Pilski	48.6	49.77	50.98	15	84.3	85.08	85.87	24	43.4	44.83	46.31	15
Pleszewski	40.0	42.95	46.11	20	118.6	120.19	121.80	9	26.7	27.63	28.60	22
Poznański	121.2	129.52	138.40	4	161.7	166.44	171.31	4	152.2	156.23	160.37	4
Rawicki	60.3	62.13	64.01	10	81.7	82.09	82.48	26	47.1	47.88	48.68	13
Słupecki	31.8	33.01	34.27	26	112.9	113.41	113.93	12	15.1	18.90	23.66	23
Szamotulski	45.0	46.16	47.35	19	96.8	97.50	98.21	19	42.3	43.72	45.20	16
Śremski	55.7	57.32	59.00	13	101.0	102.05	103.12	15	40.2	40.68	41.17	17
Wągrowiecki	35.1	36.09	37.12	23	99.6	100.18	100.77	17	18.6	19.23	19.88	25
Wolsztyński	67.4	71.96	76.82	7	76.9	78.68	80.50	27	57.3	60.14	63.11	9
Wrzesiński	38.3	39.87	41.50	21	119.8	121.24	122.69	8	34.7	36.36	38.09	18
Konin	278.5	286.08	293.87	2	245.7	247.80	249.91	3	210.2	214.00	217.87	2
Leszno	660.4	666.35	672.35	1	500.0	504.64	509.33	1	679.1	683.64	688.20	1
Choszczeński	23.9	24.12	24.34	32	29.5	29.77	30.04	34	18.6	18.77	18.95	27

stage of the research, forecasts of the values of measures characterizing the length of the distribution network were prepared. The time range of the forecasts was 2022-2023. Thanks to this research procedure, it was possible to assess the rate of change of the examined features. The need for forecasting most often results from the desire to know the future. So far, statistical research on the analyzed issues has allowed us to obtain, among others: the following results: for most of the surveyed districts, the length of the distribution network is increasing, while the decrease concerns only a few. Moreover, they are characterized by a similar growth rate. Moreover, they are characterized by a similar pace of development in all surveyed units. Other authors have also noticed similar trends in their research (see Błachut

et al. (2018) or Surówka (2023) or Kałuża-Jurczyńska et al. (2021)). During the analysis of the isochrones covered by the study, it was observed, among other things, that the studied units are characterized by statistically significant differences. Similar results can also be found in the works of other authors (Bożek & Szewczyk, 2014), (Kołodziejczyk, 2017). The values of variables (2021) characterizing the distribution network (sewage distribution network) are higher than the average in the area of influence of the Poznań-Ławica Airport in cities with county rights and the following counties: Zielona Góra, Konin, Leszno, grodziski, Gniezno, jarociński, Konin, pleszewski, Poznań and wrzesiński. As other researchers note, these are districts with good and very good conditions for socio-economic development. Moreover, they occupy very high places in the rankings. In the case of the X2 variable, the tested variable is characterized by high variability, similarly to the previous feature. Of these, only two are located in the zone of influence of another port (czarnkowsko – trzecianecki and choszczeński). It is worth emphasizing that, as other authors note, the wrzesiński district has a poorly developed gas distribution network. The variable X3 (length of the gas network in km per 100 km2 of area) was also examined. Only a few counties recorded higher than average values of this districts: gostyński, kościański, nowotomyski, jarociński, choszczeński and wrzesiński. Analyzing the catchment area of the Wrocław-Starachowice Airport, in the case of feature X1, higher than average values were recorded by districts: lubiński, oławski, wrocławski, Jelenia Góra, Legnica, Wrocław, Opole, jarociński and Leszno. This group includes Leszno, a city that occupies the highest position in the ranking in terms of the infrastructure development of counties in the Greater Poland Voivodeship. In the case of variable X2, these were cities with county rights (Jelenia Góra, Legnica, Wrocław, Opole, Leszno). In addition, districts: wrocławski, brzeski and ostrzeszowski. The length of the distribution water supply network in brzeski districts at the end of 2010 was 647.4 km and increased compared to 2004 by 183.7 km, i.e. by 39.6%. During the period under study, the number of active water supply connections leading to residential buildings and collective accommodation also increased significantly. Compared to the end of 2010, it amounted to 13.5 thousand. During the period under study, the sewerage network was also expanded in brzeski dstricts. In the area of influence of the Wrocław-Strachowice Airport, X3 features higher than the average value occur in the following units: wieruszowski, ostrowski, kluczborski, krapkowicki, opolski, pleszewski and Leszno. Districts located in the impact zone of the Bydgoszcz Szweredowo Airport were also assessed against the average. Values higher than average for the X1 variable were recorded similarly to the previous impact areas for cities with county rights and the capital of the voivodeship (Bydgoszcz, Grudziądz, Toruń and Włocławek). There are also districts in the Bydgoszcz Szweredowo Airport's impact zone: mogieliński, nakielski and żniński also located in the influence zone of Poznań Ławica Airport. They occupy similar positions in the rankings of the values of forecasted features characterizing the distribution network in both airport impact areas. In the case of the X3 variable, these are only cities with rights (Bydgoszcz, Grudziądz, Toruń and Włocławek). To sum up, it can be stated that each of the studied areas of impact of airports is characterized by different specificity and that objects located in the influence zones of at least two isochrones in the studied areas perform similarly. Additionally, they are characterized by

variability in their positions in the constructed rankings. Moreover, a two-part hypothesis was positively verified: districts located in the areas of influence of the studied airports are characterized by dynamic changes in the diversification of infrastructure development, which translates into significant variability of positions in the rankings for selected features characterizing them. The values of features characterizing infrastructure are not subject to dynamic changes, therefore the preparation of forecasts of this phenomenon should be considered reliable. The lack of publications that analyze the technical infrastructure in counties located in the impact areas of airports in Poland makes it impossible to compare the results obtained with other studies. Taking the above into account, it was only possible to refer to research conducted locally. As mentioned earlier, the presented analyzes constitute a continuation and deepening of the issues undertaken in the author's previous research.

The construction of infrastructure by public authorities is considered their obligation resulting from the need to provide residents with adequate access to public goods and services (Cilak et al., 2015). It is also worth noting that, unlike a commune, which is subject to the presumption of jurisdiction, in the case of a district, the scope of its jurisdiction has been specified enumeratively. The district's tasks can be divided into five groups: tasks in the field of technical infrastructure, tasks in the field of social infrastructure, tasks in the field of public safety and order, tasks in the field of spatial and ecological order, and tasks in the field of districts promotion and cooperation with non-governmental organizations (Sthral & Jaworska-Dębska, 2010). A very similar classification is proposed by Jan Zimmermann. According to him, the tasks of the district can be divided into: matters of technical infrastructure, matters of spatial and ecological order, matters of social infrastructure, matters of public security and defence, and matters of external representation of the districts (Zimmermann, 2018). In this context, the research carried out is of great practical importance and can constitute an important source of information for local government administration bodies, for example on the directions of development of the analyzed statistical units in terms of infrastructure development. All the more so because the infrastructure developed by local government units is an important factor in regional and local development.

Conflict of interest: none.

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Role of Global Trade in the Circular Economy

Daniela ŠÁLKOVÁ* and Aditya Ramanand SINGH

Czech University of Life Sciences Prague, Prague, Czech Republic; salkova@pef.czu.cz; singh@pef.czu.cz

* Corresponding author: salkova@pef.czu.cz

Abstract: Paper examines economic model known as upcycling, which seeks to minimize environmental damage by maximizing the reuse of resources. The use of raw materials, production and consumption that underpin the vertical economic system promoted by global trade has serious social and environmental consequences. The study highlights the opportunities and threats of global exchange in the context of supply chain transformation. Notwithstanding the considerable difficulties, the result suggests that global trade can contribute to the development of a circular economy by increasing productivity, reducing pollution, and encouraging more environmentally responsible production and consumption. The conclusions and suggestions relate to the findings from GRETL and how policy makers, firms and individuals could accelerate the uptake of recycling and reuse in global trade.

Keywords: circular economy; global trade; resources; key challenges; global cooperation

JEL Classification: M31; O13; O44

1. Introduction

The world faces an urgent need to move to a more sustainable economic model that not only promotes economic growth but also reduces environmental impacts and promotes social justice (Geissdoerfer et al., 2017). A linear model of production and consumption (take-make-use-dispose) in which items are produced from raw materials, sold, used, and then disposed through landfilling or trash incineration, has dominated the industrial evolution. The linear model's fundamental presumptions, however, are no longer valid in the current global context, and a number of significant trends are endangering its viability, necessitating the need for an alternative economic model (Vidal-Ayuso et al., 2023). Circular economy is a framework that offers potential solutions for these challenges by promoting a regenerative approach to resource use and waste management (Kirchherr et al., 2023). Separating actual consumption of raw resources from economic growth can achieved through circular economy efforts to close, expand and reduce material loops (Scheel et al., 2020). Methods that could lead to a reduction in the rate of resource extraction and use are part of the system of transition to a circular economy (European Commission, 2019). For greater efficiency, this promotes sustainable management of materials and greater resource efficiency (OECD, 2021). The circular economy started with to reduce the amount of waste produced but has now expanded into a comprehensive strategy to increase the sustainability of resource use (Velenturf & Purnell, 2021). The potential it represents not only for resource savings and improved health and environmental outcomes, but also for business and environmental and financial diversification, is an important element of the attractiveness of the circular economy

(Feng & Goli, 2023). Global supply chains, final value chains and business services are just some of the ways in which circular economy policies and initiatives are linked to global trade (Hofstetter et al., 2021). Economies of scale and new jobs created by trade are two ways in which it can support the functioning of the circular economy (European Commission, 2018).

Private sector needs help in overcoming the barriers to the implementation of circular trading models worldwide (Kirchherr et al., 2017). It is essential to avoid trade that has adverse effects on the environment (Buterbaugh, 2022). More work is needed to be done to ensure that the objectives of trade and the circular economy are compatible (European Parliament, 2023). For example, the transition to a circular economy may have undesirable consequences for supply chains in extractive industries (Castro et al., 2022). However, certain key minerals will always be needed (Azevedo et al., 2022). It is important to guarantee a fair and environmentally sound transformation of the global trade in extractive raw materials (Vela Almeida et al., 2023). The circular economy can also have an impact on trade in goods and services (Barrie & Schröder, 2022). The transition to a circular economy usually involves a greater degree of involvement of the service sector, such as the production of products maintenance, repair and servicing systems, and can create new opportunities for service trade (Reike et al., 2018). The transition to a global circular economy is gradually coming to the attention of political leaders around the world (Ellen MacArthur Foundation & McKinsey & Company, 2014). The purpose of this effort is to promote the circular economy not only within a specific jurisdiction, but also by seeking synergies with other countries in hopes of achieving a material circular economy and ultimately decoupling the circular economy from the resource consumption of the overall economy at the macro level (Di Vaio et al., 2023). Businesses must reduce waste, maximise product life through maintenance and repair, and recycle old parts (Mohammed et al., 2021). Sharing economy and goods-as-a-service business models of this type increase overall efficiency (Curtis, 2021). The analysis showed that supply chain executives want to double their profits from circular products and services by 2030 (Bimpizas-Pinis et al., 2022). In the face of disruption, key corporate representatives are using circular products and business strategies to boost revenue, save costs and build resilience in a low-carbon world. More than half of circular executives surveyed see this economy as critical to future success (Karman, 2022). As more companies implement circular business strategies, society will benefit more (Flores-Tapia et al., 2023). However, most companies still lack a plan to move to a circular business model. This kind of change can be difficult to implement, and success is slow to come (Aarikka-Stenroos et al., 2022). Existing items and processes can be circulated. This could create a suitable framework for a business strategy (Shopova et al., 2023). Buyback programs, repairs, refurbishment, resale, and the use of renewable and recycled materials can extend the life of products (Mallick et al., 2023). The data shows that consumers are ready to switch from buying consumer goods to buying access to products as part of a service, i.e., a package that guarantees reliability, ease, and return (Wang et al., 2020). Businesses that accept circular business models and strategies before it's too late can work with governments to accelerate this shift (Barros et al., 2021).

The main aim of the article is to evaluate the role of global trade in circular economic model to meet the demand of global resources, which is increasing year by year.

2. Methodology

The research uses a systems approach that integrates economic and environmental variables and analyses the role of the circular economy in global trade. The study includes a comparative analysis of different trading regions to provide a global perspective on circular economy practices. We adopt a longitudinal study design and analyze trends over the past decade to assess the evolution of the circular economy in the context of global trade. Our analysis incorporates a multi-sectoral approach and assesses the impacts of circular economy practices in different sectors involved in global trade. Scenario analysis was used to predict the possible future impacts of increased adoption of the circular economy on global trade dynamics. The data validation process ensures the accuracy and reliability of the trade and economic data. The methodology integrates quantitative research, using Eurostat data to discern patterns between global trade and circular economy practices through statistical techniques including regression analysis and correlation matrices. At the same time, it enriches this analysis with a qualitative dimension that explores the differential impacts and practicalities of circular economy initiatives through case studies and interviews with experts. This dual approach not only provides a comprehensive understanding of the role of circular economy in global trade, but also highlights the economic and environmental rationale for its adoption, even in zero waste scenarios. By combining these analytical dimensions, the study offers a nuanced view of the interdependencies between global trade, sustainability and circular economy practices that is consistent with current research and real-world applications. The study explores the implications and assesses how different global trade regulations and policies may affect the uptake of circular economy practices. Finally, a sensitivity analysis was included to test the robustness of our findings to different assumptions and external factors.

Research focuses on a circular economy model that examines the global business practices. For the quantitative analysis, data on global trade and circular economy practices were obtained from Eurostat. The data included statistics on trade volumes, trade flows. The collected data was cleaned and prepared for analysis which included checking for missing values, outliers, and inconsistencies in the data. The data was analyzed using statistical techniques such as regression analysis, ordinary least squares, correlation matrices to identify trends, patterns and relationships between global trade and circular economy practices. Reports and visualizations of the analyzed results were created to help convey the findings and insights. The results of the analysis and lessons learned were synthesized to draw conclusions and make recommendations to strengthen the integration of circular economy principles into global trade practice.

The time series analysis exploited the relationship between the private and public sectors, investment and gross value added in the circular economy sectors and several factors that can influence this relationship. The data covers the period from 2011 to 2020 for trade with the European Union (Table 1). These variables are important because they are all potentially relevant in determining the relationship between private investment and gross value added in circular economy sectors. The per capita production of packaging waste and

the recycling rate of both packaging and municipal waste could reflect the level of concern for the environment and sustainability in the economy. On the other hand, private investment and gross value added in the circular economy sectors promote sustainable practices and have contributed to lower waste production and higher recycling rates. The data were analyzed in GRETL using different statistical methods to understand the relationships between these variables and private investments and gross value added in the circular economy sectors.

Table 1. Data of European Union for analysis in GRETL

Year	Private investment and gross value added related to circular economy sectors (mil. euro)	Generation of packaging waste per capita (kg per capita)	Recycling rate of packaging waste by type of packaging rate (%)	Recycling rate of municipal waste (%)	Generation of municipal waste per capita (kg per capita)
2011	110,100	157	64	38	499
2012	108,900	154	65	40	488
2013	108,800	156	65	41	479
2014	113,100	161	66	43	478
2015	114,900	165	66	44	480
2016	117,700	168	67	45	493
2017	125,700	173	67	46	499
2018	130,800	173	65	46	500
2019	139,100	177	64	47	504
2020	139,100	177	64	49	521

For the qualitative analysis, the strengths, and weaknesses of the evaluation of the involvement of global trade in the circular economy model were examined. The qualitative analysis is flexible and allows the approach to be adapted as new information was gathered. For this reason, the analysis was refined to the most relevant aspects of the study. The circular economy model in global trade is seen in its entirety through the lens of qualitative analysis. It was about understanding the nuances of the model and its impact on different stakeholders such as corporations, governments, and consumers. The validity of the results of the study was enhanced using qualitative analysis. By using multiple data sources, including interviews, observations and case studies, the findings were verified to be valid. However, the findings of qualitative research are difficult to generalize. The findings of a qualitative study are specific to the setting in which the research was conducted and cannot be applied to other situations. However, qualitative analysis is subjective, and conclusions may be influenced by the biases and interpretations of a particular author. Qualitative analysis required a limited sample size, which is what limits the generalizability of the results. The qualitative assessment of global trade engagement provided comprehensive insights into the implementation and effect of the circular economy model. Although it had limitations, including poor generalizability and subjectivity, these shortcomings were mitigated using multiple data sources. Overall, the qualitative analysis provided a valuable tool for evaluating the circular economy model in global trade.

3. Results

The analysis looked at how different factors can affect private investment and value added, how much money is earned from business activity. It looked at how much packaging waste per person, how much of this packaging waste is recycled by households, and how much municipal waste is recycled per person. It has been found that if there is more packaging waste per person and more of this packaging households recycle more of this packaging, then private investment and gross value-added increase. However, if more municipal waste is recycled, then private investment and gross value added may decrease. The amount of municipal waste per person does not seem to have much effect (Table 2).

Table 2. Ordinary least square

	Coefficient	Std. Error	t-ratio	p-value
Const	1,985.68	12.3008	161.4	<0.0001
Private investment and gross value	7.37568e-05	6.98939e-05	1.055	0.3508
Generation of packaging waste per ca	0.0346150	0.0784984	0.4410	0.6820
Recycling rate of packaging waste	−0.0987964	0.226610	−0.4360	0.6854
Recycling rate of municipal waste	0.577534	0.110246	5.239	0.0063
Generation of municipal waste per ca	−0.00757182	0.0140303	−0.5397	0.6181
Mean dependent var	2015.500	S.D. var	dependent	3.027650
Sum squared resid	0.343068	S.E. of reg.	S.E. of reg.	0.292860
R-squared	0.995842	Adjusted	R-squared	0.990644
F (5, 4)	191.5817	P-value(F)	P-value(F)	0.000075
Log-likelihood	2.672675	Akaike criterion	Akaike criterion	6.654650
Schwarz criterion	8.470161	Hannan-Quinn	Hannan-Quinn	4.663040

$y1t = 89{,}596.5 + 947.402\ x1t - 2{,}836.59\ x2t + 808.174\ x3t + 47.7851\ x4t + ut$

$y1t$ = Private investment and gross value added related to circular economy sectors (m€)

$x1t$ = Generation of packaging waste per capita (kg) per capita

$x2t$ = Recycling rate of packaging waste by type of packaging (%)

$x3t$ = Recycling rate of municipal waste (%)

$x4t$ = Generation of municipal waste per capita (kg) per capita

If all the variables are 0 then the value of Private investment and gross value added to circular economy sectors will be 89,596.5 m€. If only Generation of packaging waste per capita (kg) per capita increased by 1 unit, then private investment and gross value added related to circular economy sectors increased by 947.402. If recycling rate of packaging waste by type of packaging increased by 1% then private investment and gross value added related to circular economy sectors decreased by -2,836.59. If recycling rate of municipal waste increased by 1% then private investment and gross value added related to circular economy sectors increased by 808.174. If generation of municipal waste per capita increased by 1 unit then private investment and gross value added related to circular economy sectors increased by 47.7851. The P-value is 0.000074 which is much less than 0.05, so this is an appropriate model.

Circular economy goes beyond just waste management. The underlying principle involves rethinking and redesigning economic systems to not only eliminate waste in its physical form, but to address inefficiencies in resource use. There are a number of benefits to investing in circular economy, even in a zero-waste scenario. Circular economy promotes resource efficiency and reduces dependence on raw materials. This is particularly important given the scarcity of many resources and the increasing volatility of their supply chains. Investment in the circular economy sector promotes innovation in product design, materials science and supply chain management. These innovations support economic diversification, creating new markets and jobs. The circular economy reduces the impact of resource price volatility and supply chain disruptions, leading to a more stable and resilient economy. Reducing resource extraction and waste also has clear environmental benefits, including lower greenhouse gas emissions, reduced pollution and the preservation of natural ecosystems. From a global trade perspective, engaging in circular economy practices can increase a country's competitiveness in global markets. It demonstrates a commitment to sustainable practices that are increasingly valued by consumers and international trading partners. Circular economy strategies can lead to social benefits, including job creation in new industries related to recycling, upcycling and sustainable product design. Even in a hypothetical zero-waste scenario, the circular economy offers a comprehensive framework for sustainable economic development. It not only addresses environmental issues but also contributes to economic resilience, innovation and social well-being.

The correlation between the increase in recycling rates and the decrease in private investment and gross value added in the circular economy sectors requires a nuanced understanding. It is essential to take into account that the circular economy involves various interrelated elements, including resource efficiency, innovation and economic diversification. Therefore, a simple causal relationship between increased recycling rates and reduced investment may not capture the complexity of the circular economy. It is necessary to explore other influencing factors such as market dynamics, policy frameworks, technological advances and global economic trends that may also play a significant role in this observed phenomenon. The relationship between waste generation and investment in the circular economy sectors is not as straightforward as the causal link that would suggest that "more investment requires more waste". The observed correlation in the data may suggest differential dynamics, where increased waste generation may stimulate investment in circular economy practices, but this does not inherently imply that waste generation is a desirable or necessary condition for such investment. Thus, while increased waste production may temporarily stimulate investment in the circular economy sector due to the immediate demand for waste management solutions, the longer-term objective is to create a more sustainable economic system that thrives on the basis of lower resource use and waste production. The focus should be on creating a regenerative economy in which waste is minimised and resources are continuously reused, creating a net positive impact on the economy and the environment.

Table 3. Heteroskedasticity-corrected

	Coefficient	Std. Error	t-ratio	p-value
Const	116,613	41,210.4	2.830	0.0367
Generation of packaging waste per ca	1,145.63	182.668	6.272	0.0015
Recycling rate of packaging waste	−2,987.67	445.674	−6.704	0.0011
Recycling rate of municipal waste	614.248	413.036	1.487	0.1971
Generation of municipal waste per ca	−36.2648	59.8413	−0.6060	0.5710
Statistics based on the weighted data				
Sum squared resid	6.652792	S.E. of regression		1.153498
R-squared	0.996389	Adjusted R-squared		0.993501
F(4, 5)	344.9596	P-value(F)		2.73e-06
Log-likelihood	−12.15164	Akaike criterion		34.30329
Schwarz criterion	35.81621	Hannan-Quinn		32.64361
Statistics based on the original data				
Mean dependent var	120,820.0	S.D. dependent var		12,007.39
Sum squared resid	22,399,714	S.E. of regression		2,116.588

The output shows the results of running a LASSO regression using the alternating direction method of multipliers (ADMM) algorithm on a dataset with 10 observations and a dependent variable called Private investment and gross value added. The goal of LASSO regression is to select a subset of independent variables that are most important for predicting the dependent variable, while also reducing the impact of any irrelevant variables. The lambda value used in this regression is 0.476095, which corresponds to a lambda/n ratio of 0.04761. The degree of freedom (df) is 1, and the criterion value is 0.386667. The R-squared value is 0.68, indicating that the model explains 68% of the variation in the dependent variable. The Bayesian Information Criterion (BIC) is a measure of model fit that balances the trade-off between goodness of fit and model complexity. In this case, the BIC value is 19.2871 for a lambda-fraction of 0.5. The lower the BIC value, the better the model fit. The LASSO coefficients show the estimated effect of the independent variables on the dependent variable. The intercept is 12,758.9 and the only non-zero coefficient is for the independent variable called "Generation of packaging waste per capita", which has a coefficient of 650.578. This suggests that the generation of packaging waste per capita is an important predictor of private investment and gross value added.

Private investment can lead to increased economic activity, which can lead to increased municipal waste and packaging waste production (Fig 1). However, private investment can also lead to the development of more efficient and sustainable waste management practices, which can contribute to a reduction in waste generation, the total amount of municipal waste and packaging waste produced.

The concept of engaging in global trade within the circular economy model emphasises the recycling and reuse of materials and resources within the economy. An evaluation of this model was also carried out using qualitative analysis. The qualitative analysis sheds light on the barriers, benefits and opportunities that the circular economy model presents in global trade. Data research shows that studies on the intersection of the circular economy and the

global trade is gradually increasing, despite the low baseline. Eighty percent or more of articles and publications were produced during 2019-2021 (Barrie & Schröder, 2022). Both the academic and the so-called grey literature account for most of the published work (mainly including publications by international organisations). In the global circular economy, revenues from used, leased, and refurbished products alone reached approximately $339 billion in 2022. This is expected to double in 2026 (Mandpe et al., 2023).
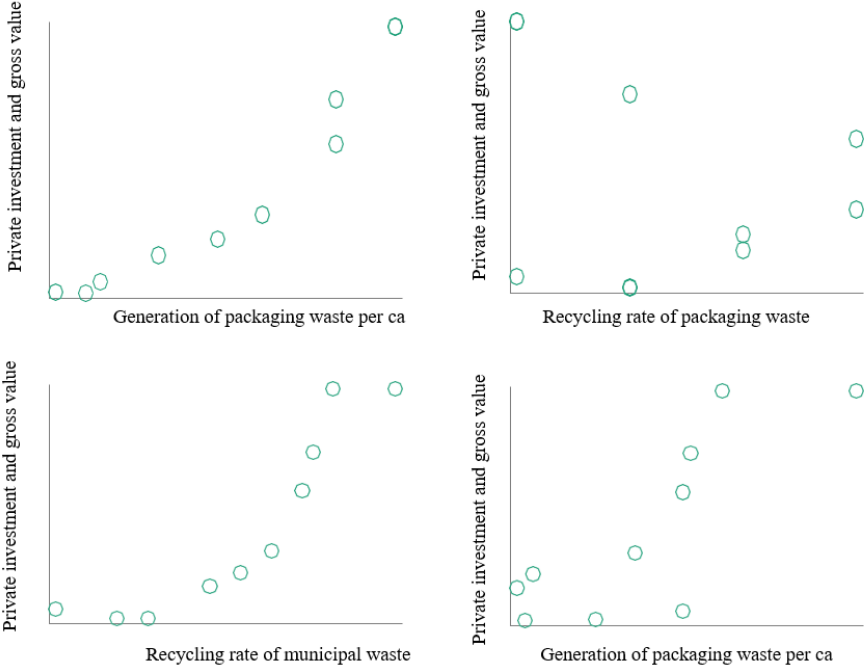

Figure 1. Scatter plot for variables (GRETL)

The global trade in plastic waste increased sharply after 1990 and peaked between 2006 and 2016. This was followed by a period of stability in world trade, with imports gradually declining. The Green Fence campaign, leading to a reduction in the amount of plastic trash that can be dumped in China and the subsequent shipment of this trash back to the countries of origin, was a major factor influencing the global decline in exports. The global volume of plastic imports and exports has been affected by the lack of waste disposal facilities elsewhere, in most cases, plastic waste is sent rather than being imported. The inability of countries to process their plastic waste is indicative of the lack of systematic management of plastic waste. In 2020, EU Member States exported 38.4 million tonnes of recyclables (including recyclable waste and scrap and secondary raw materials) to non-EU countries. These exports have been on the rise since 2004 and are expected to peak in 2020 (an increase of 70% compared to 2004 levels). In contrast, the European Union (EU) imported 44.7 million tonnes of recyclables from non-EU countries in 2020, a decrease of 0.2 per cent from 45.0 million tonnes in 2019 and an increase of about 2 per cent from 33.8 million tonnes in 2004 (43.7 million tonnes) (Midova et al., 2023).

4. Discussion

One of the main objectives of the circular economy is to reduce environmental damage (Konietzko et al., 2020), which is well known as one of the area's most susceptible to external

costs. This shows the importance of global trade as an important element of the circular economy for businesses (OECD, 2018), which are the source of negative externalities if circular economy businesses and business models are to prosper. There are many ways of looking at global trade and its role in the circular economy. The study focused on a circular economy model that examines global trade practices. There is a link between the private and public sectors, investment and gross value added, including the factors that can influence this relationship (Nguyen & Trinh, 2018). Municipal waste recycling rates, private investment and gross value added are also considered important elements of the transition of the global business model to a circular economy in the study (Hysa et al., 2020). Various factors can affect trade in the context of the circular economy (Pomberger et al., 2017). An enabling financial environment, regardless of the source of funding, promotes sustainable development. In many cases, it is investment, whether at the state, business, or household level, that is the limiting factor in efforts to achieve circularity, even though it is an integral part of any plan to address circularity (Agyapong & Tweneboah, 2023).

Another important element of the model is the rate of waste and, relatedly, the rate of recycling. Waste management and recycling rates are important elements of the transition to a circular economy, with reference to the priority areas of the Central Europe Action Plan (European Commission, 2015), and therefore need to be given due consideration when changing the business model. An important indicator here is the level of packaging waste per person, how much of this packaging waste is recycled by households and how much municipal waste is recycled per person. It was found that higher recycling rates per person and higher levels of recycling by households increases private investment and gross value added. The quality of waste management directly affects the profitability of companies, as confirmed by a study (Danon et al., 2022). A further important prerequisite for the transition to a circular economy is investment ("The New Industrial Strategy for Europe," 2021).and in this context also innovation (Aid et al., 2016).

The results of the paper are consistent with some other recent studies in which the authors developed models for the transition to a circular economy. In the first study (Busu & Trica, 2019) circular materials, municipal waste, trade in circular materials, labour productivity, environmental tax and resource productivity were all significant and positive for circular economic growth. A second study (Hill et al., 2020) described that resource productivity, recycling rates, environmental employment and innovation are also important for further economic and environmental growth. Other studies confirm that the importance of recycling rates and environmental innovation are also important factors for sustainable development and economic stability (Busu & Nedelcu, 2018; Lieder & Rashid, 2016). Similar to (Murray et al., 2017) and (Busu & Nedelcu, 2018), our results conclude that recycling rates have a positive impact on the transition to a circular economy.

5. Conclusion

Circular business models must be recognised as an integral part of the economy and must be given the resources they deserve. The importance of classifying indigenous materials according to aspects of business strategy design highlights the need to understand the

fundamentals of circular business models. This is essential for understanding the many forms that circular business models can take on and the different ways in which they can be implemented. According to the criterion Circular Business Model: Synthesis and Framework for growth, there should be a single model or framework that guides the creation and implementation of those models. Circular business models can be scaled and expanded by using a framework based on a synthesis of current knowledge and best practices.

The study investigated how global trade affects the transition to a more resource-efficient circular economy. The final question to be answered is how circular economy and trade policies could be linked to inspire a shift in resource use away from economic growth at the global level without causing additional barriers to global trade as well as undesirable environmental consequences. The small amount of previous research that has been published on this topic provides a strong incentive for further investigation in this area. Private investment can contribute to the growth of businesses and industries that produce goods, including packaged products. As businesses expand and produce more goods, they may also produce more packaging waste as a by-product of their production processes. Similarly, GVA can be an indicator of the level of economic activity in a country in a particular sector, including manufacturing and packaging. As the value of goods produced in these industries increases, this may also lead to an increase in the amount of goods produced and packaging waste generated. LASSO regression using the ADMM algorithm identified one significant predictor for the dependent variable, effectively reducing the influence of all irrelevant variables. The findings can help in making decisions on how to promote economic growth through a circular economy with environmental care.

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assess its parts individually. The gradual evolution of Scrum into hybrid approaches is a topic covered recently and will likely grow in the future (Reiff & Schlegel, 2022).

Fast project delivery is one of the expectations of companies implementing agile methods, including Scrum (Cao et al., 2009; Hayat et al., 2019; Kuhrmann et al., 2022; Serrador & Pinto, 2015). This topic is popular both in academic literature and especially among practitioners. At the same time, many studies point to the weak methodological quality of such studies and their focus on practitioners rather than rigorous scientific knowledge (Abrahamsson et al., 2009; Dingsøyr et al., 2012). This is particularly evident in the frequent failure to define the essential terms and mechanisms that actually affect project speed. Often, the term speed or fast delivery is not clearly defined, and it is not clear what exactly is being accelerated (Conforto et al., 2014).

The presented literature review aims to concentrate the fragmented knowledge about the contribution of Scrum to the speed of change delivery. It also aims to clarify the fragmented perception of what fast delivery actually means and what it is composed of. The review will also focus on the individual practices of Scrum and their contribution to the speed of delivery, as this is essential for emerging hybrid approaches.

1.2. Scrum

Scrum is one of the agile methods and is currently the most widespread representative of this group of approaches (Anghel et al., 2022; Digital.ai, 2022). It is based on the principles of the Agile Manifesto and defines a set of roles, events, and artifacts that together form a framework for the delivery of change (Schwaber & Sutherland, 2020). Scrum is most often used in the development of software products, but its use is gradually expanding to other areas (Digital.ai, 2022).

Scrum itself is defined by the Scrum Guide, which is the authoritative source for the definition of this framework (Schwaber & Sutherland, 2020). The Scrum Guide is relatively brief and leaves a lot of freedom in the specific implementation of the framework. This is one of the reasons why Scrum is implemented in practice in many different ways and why individual practices are often added or removed (Diebold et al., 2015).

The basic building blocks of Scrum are three roles (Product Owner, Scrum Master, and Developers), five events (Sprint, Sprint Planning, Daily Scrum, Sprint Review, and Sprint Retrospective), and three artifacts (Product Backlog, Sprint Backlog, and Increment) (Schwaber & Sutherland, 2020).

evaluate its individual practices contributions and, more precariously, to be able to assess for which objectives it is an appropriate method (Krupa et al., 2023; Reiff & Schlegel, 2022).

1.2. Research Gap and Problem Statements

The above leads us to the need to oppose publications that describe entire methodologies in a cursory manner and delve into a deeper analysis of the individuality that is the speed of delivery. Thus, to clarify the situation, whether Scrum is the appropriate method if the priority is to deliver change as quickly as possible. To date, there is no clear direction of publications providing answer and there are also conflicting arguments about the project time contribution (Cardozo et al., 2010; Mkoba & Marnewick, 2020). On the one hand, there are publications talking about the adoption of Scrum because of its speed of delivery compared to traditional management. On the other hand, there is criticism of Scrum directed towards the high level of bureaucracy, frequent lengthy meetings, and the dissatisfaction of roles like developers that they do not have time for productive work within this method (Anghel et al., 2022; Fisher & Bankston, 2009). For these reasons, the paper aims to clarify the "How does Scrum, as an agile methods representative, contribute to the speed of change delivery compared to traditional approaches?"

1.3. Relevance to Industry and Academia

Nowadays, when agile practices are not only applied as a whole but are combined with elements of traditional management or are more adapted to the context of the enterprise, it is all the more important to understand Scrum not only as a whole but also how its parts contribute to the enterprise (Krupa et al., 2023). This includes clarifying whether speed of delivery is an appropriate motivation for applying Scrum. This will enable more explicit decision-making about the proper method for a given project or organization.

At the same time, this focus of the publication benefits academia on multiple levels. Besides answering the research question that raises ambiguity, the paper aims to balance publications that try to go through a cross-sectional analysis of the whole method or several at the same time, which condemns them to superficiality. Further, by clarifying the topic of speed of delivery in the context of agile project management, which, in fact, contains many concepts and indicators of project time quality (Mkoba & Marnewick, 2020).

2. Methodology

The literature review research method was chosen because the area of agile development contains many publications that touch on the speed of delivery, and the problematization under examination is based on their inconsistency and ambiguity (Brito & Vieira, 2017; Gregory et al., 2016; Lundene & Mohagheghi, 2018). At the same time, the dominant trend of agilization is falling away, corrections and a more sober assessment of agile practices are taking place, which is represented, for example, by the subsequent development of hybrid project management (Gregory et al., 2016; Krupa et al., 2023). The literature review also provides us with an opportunity to unpack the reasons for potentially conflicting claims about whether scrum is a preferable approach when trying to deliver change in the shortest time.

Data collection was based on information from the main world research databases Web of Science and Scopus, which are generally accepted and contain a broad base of publications (Martín-Martín et al., 2018). Both of them were searched through the available attributes, including title, abstract and keywords. The search query always required the content of two words expressing Scrum and a synonym for speed of delivery. Specifically, the queries were "Scrum" AND "speed", "Scrum" AND "time", "Scrum" AND "efficiency", "Scrum" AND "slow", "Scrum" AND "fast", "Scrum" AND "duration", "Scrum" AND "velocity" and "Scrum" AND "pace". The retrieved records were exported to Excel and, after removing duplicates, were further analyzed.

The selection criteria were, therefore, the presence in the mentioned databases. Furthermore, mention of the Scrum methodology under study and terms indicating a reflection of the speed of change delivery. Only publications in English were included. The sample was not limited by location or industry. The exclusion criteria were the lack of quality of the publications, which was typically manifested by the lack of details about the empirical phase of the research or if claims about the speed of delivery were not based on academic literature or data.

The literature review followed standard PRISMA guidelines. Eight queries searched in two databases yielded a total of 3,073 records, among which there were 499 duplicates. Further consolidation occurred during the analysis phase.

Next, the screening relied on the use of AS Review, which is a software tool used specifically for literature review (Van De Schoot et al., 2021). With the tool support, the researcher eliminates or keeps articles based on title and abstract according to relevance. The software, using machine learning, then suggests other relevant articles based on the previous decisions of a researcher and manual intervention, which were included in the export from the research databases. This continues until only non-relevant articles remain. This system allows larger samples of articles to be browsed, which was the case for this research with an initial listing of over 3,000 results. After screening with this tool, 98 relevant records remained.

This was followed by a full review of these 98 papers to confirm their relevance and their potential to contribute to this review, which led to a final number of 38 included papers. The content analysis was executed with the support of MAXQDA24, a tool that allows markup and encoding of text. For each record, research parameters such as location, industry, or type of change were tagged for review. Next, statements about Scrum's contribution to delivery speed were coded and then synthesized into the themes discussed in the Results section.

3. Results

3.1. Overview of the Research Papers

The reviewed articles follow a standard where the application of change management frameworks, including agile ones, is mainly used in the IT sector. At the same time, however, the range of industries covered is relatively diverse, containing research from construction, pharmaceuticals, and university settings (Azanha et al., 2017). There is even more diversity within the regional distribution, where although the USA is the top-ranked region, there are

data from South America (Ormeño Zender & García De Soto, 2021), Africa (Mkoba & Marnewick, 2020), Europe (Plateaux et al., 2020), and Asian countries, where India is dominantly represented (Cho et al., 2006). Although no time frame filter has been applied, all articles are found after 2000, and new publications have been added in recent years. The efforts of the researchers should be acknowledged; given the solid empirical database, they repeatedly use mixed methods; otherwise, quantitative and qualitative research methods are relatively evenly represented. Regarding collection methods, case studies are the most typical representative, and second in order are questionnaires, which repeatedly contrast with case studies from a cross-industry perspective.

The unifying element is the optimistic view of Scrum, which is visible, especially in abstracts and introductions of publications, and only after a more profound look is it evident that for many, the optimistic view is only an expectation or based on the reference of earlier studies. At the same time, there is a wide divergence on what project or initiative time criteria Scrum influences, as discussed in the following subsection (Iqbal et al., 2019).

3.2. The Time Aspect of the Project

Outside the scope of this study is the implementation phase of the methodology, and the subject matter is only the delivery of change in an already established framework. Yet, relevant studies are repetitive in recognizing that sufficient time must be left for the introduction of Scrum and agility so a company is fully capable to benefit from them (Anghel et al., 2022; Heimgärtner & Solanki, 2014).

One of the objectives of this paper was to confirm or refute the literature's consensus on whether Scrum contributes to increased speed of change delivery. Although readers may find many publications addressing the time aspect of Scrum and highlighting its benefits, there appears to be a wide variety of perceptions of what time criteria and, therefore, benefits the publications report (Mkoba & Marnewick, 2020; Plateaux et al., 2020). The distribution of these time criteria is quantified in Table 1. The most cited benefit is time-to-market, which expresses the time from the start of a project or initiative to the impact of the initial incremental changes on users or customers (Peixoto & Silva, 2009; Shirokova et al., 2020). While this is undoubtedly an essential aspect of the project, providing, among other things, early feedback and greater customer satisfaction, it does not reduce the project delivery time but only more tactfully phases the delivery of change (Goyal et al., 2023; Mkoba & Marnewick, 2020). This, in turn, can negatively affect the overall length of the project or the change delivery initiative. Although publications refer to fast delivery, this naming can be misleading to the reader as it does not target faster change delivery. In the literature, there is also a lead time, which contains the exact mechanism described in relation to time-to-market; only it starts at the point of the change hypothesis and ends with its partial delivery to the customer. At the same time, there have been publications that describe Scrum as fast delivery, with flexibility behind its description, which is widely agreed upon as a framework that can react quickly to and reflect external changes. (Anghel et al., 2022; Peixoto & Silva, 2009)

A comparable number of publications deal with delivering the scope in the shortest unit of time, trying to meet the planned time without exceeding it, criteria that reflect the desire

to speed up the delivery of the initiative or the project as a whole, and the influences on these variables based on Scrum are discussed below.

Table 1 below indicates the variance of publications in the focus on the contribution of Scrum on the time aspects of change. There are individual cases of specific time criteria where, for example, according to one study, Scrum is the methodology in which employees feel the most time pressure (Hidalgo, 2019). Not only is there a wide variance in the perceived importance of Scrum velocity between publications, but there are visible contradictions and confusion between different time criteria within the same publication, with delivery velocity and time to market being confused (Mkoba & Marnewick, 2020).

Table 1. Focus of reviewed papers on the time perspective contribution of Scrum

Primary time indicator	Number of papers[1]
Time to deliver	11
Time-to-market, lead time	10
Speed of delivering scope	6
Schedule handling	4
Time spent	4
Efficiency	3
Frequency of added value	2
Reaction to changes	2
Effort to deliver task	1
Time pressure	1
Velocity	1

[1]More indicators could be identified within one paper. Therefore, the sum may be higher than the number of included papers.

When analysing the project time and speed aspect of using each framework, it is important to keep in mind the publication-validated mechanism where speed or slowness can translate into other aspects of projects such as scope or quality (Plateaux et al., 2020). Even with Scrum, these manifestations are noted: "Many issues arise during the implementation of interaction detailed design. Developers may not solve these issues in order to save time during development" (Peixoto & Silva, 2009).

3.3. Positive Practices Contributing to the Delivery Time

Intentionally, the wording of improving the time for a project or an initiative is used. Associated with Agile and Scrum is a retreat from the project-based notion of change in favour of building teams and a structure that delivers long-term or multiple changes through the continuous development of multiple initiatives. Therefore, it is not always about projects. This practise is perceived as a positive pattern of Scrum, which brings additional efficiencies from better team interplay and stabilization of the change delivery mechanism, saving time from repeatedly building a temporary organization as in traditional change management (Cho et al. 2006; Fitzgerald & Hartnett, 2005).

According to multiple studies, when defining or assessing speed of project or initiative, there should be consideration reimplementation or rework (Chumpitaz et al., 2020;

Heimgärtner & Solanki, 2014). In another words, assessment of delivering scope over time should involve changes in scope incoming during the project. If this approach is taken, there is a consensus on the benefits of agile methodology in the sense that by continuously collecting feedback from an early stage, Scrum is more effectively directed towards delivering a corrected scope for a project or initiative. In contrast, reflecting the need for scope change occurs more slowly in more traditional approaches. This advantage is reflected in the following conclusions: "The whole development was accelerated through continuous customer involvement and early feedback. This also helped in finalizing the requirements faster and earlier" (Heimgärtner & Solanki, 2014, p. 127).

These given processes that require laborious decision-making by all lead to Scrum being labeled as bureaucratic. However, it is also true that compared to traditional management, significantly less management documentation is produced, which is undoubtedly a saving that has a positive contribution on the speed of delivery (Fisher & Bankston, 2009). Inextricably linked to this is the workload estimation mechanism, whereby it only determines the relative workload to other activities and does not attempt to accurately reflect the money and time that tends to be required by management. This frees up time to actually implement the change (Li et al., 2019).

For a comprehensive analysis, it may be a misleading definition to consider the methodology, in our case, the impacts on speed, through the lens of only one initiative or project. Within the literature reviewed, there is a consensus on the functionality of the concept of continuous improvement, where a series of measures, such as Retrospectives, positively impacts project effectiveness, particularly over longer time horizons beyond a single initiative. This is also true with respect to existing project improvement mechanisms in traditional approaches, but Scrum is superior in this regard (Shirokova et al., 2020).

Scrum has a prevalent positive effect where there are challenging and significant needs for communication, which was confirmed among the environments studied, for example, the construction industry (Streule et al., 2016). Some studies even conclude that the improvements in communication outweigh the adverse time effects of Scrum in terms of high bureaucracy and meeting time (Chumpitaz et al., 2020).

3.4. Negative Practices Contributing to the Delivery Time

One of the negative time contributions of Scrum is its relative unsuitability for changes requiring the coordination of multiple teams with interdependent timing dependencies (Fisher & Bankston, 2009). Scrum has proven itself as a framework for managing individual teams, and therefore, scaled agile frameworks have proven helpful in orchestrating larger units up to organizations (Bass & Salameh, 2020; Cho et al., 2006). Poor coordination of mutual impacts leads to its late identification and planning. A related constraint reported in the literature is prioritization mechanisms (De O. Melo et al., 2013; Uikey & Suman, 2012). When the teams create their independent priority lists for themselves, there is no appropriate mechanism in Team A's work list to reflect that it contains a requirement that Team B is waiting for and stalling.

One of the characteristic elements is the decentralization of management in the sense of shifting it from the manager to the team to be exercised in newly designated meetings where the whole team makes decisions (Piedrahita et al., 2023). In doing so, it is necessary to explain and achieve the understanding of each member of the team and then vote, which is naturally more time-consuming and costly compared to the decision of the manager alone, although following the wisdom of the crowd mechanism leads to better decisions (Cho et al., 2006; Qayyum et al., 2020). As a result of the study, they repeatedly come up with conclusions such as: "The Scrum methodology received mixed reactions, with respondents calling it "timeconsuming""(Anghel et al., 2022, p. 52).

Associated with Scrum is the practice of iterative work in cycles, where, for example, part of the output is delivered every two weeks through production and quality control. This practice has two opposing effects impacting the length of delivery. First, compared to the sequential approach, the iterative approach may have a negative effect on time, and it adds redundant work represented, for example, by testing. A tester in each iteration ideally has to test the entire product to check that new changes have not damaged the previously produced work. This is called regression testing in the context of software development, and if other approaches principally test predominantly once at the end, the time for it is significantly reduced. This negative effect is formulated in one of the studies as follows: "Furthermore, the results suggested that all of the team factors are positively correlated, apart from leader meetings and, unit and regression testing" (Iqbal et al., 2019, p.7). The second contradictory effect is that if testing finds bugs that need to be fixed, in Scrum's iterative approach, they are uncovered sooner, and fixing them is easier because the developer does not have to backtrack as much mentally, and also encounters fewer bugs at one point in time, which are easier to deal with as a rule than if he or she had checked them all in at the end of the change project (Fitzgerald & Hartnett, 2005). Although this example is given for the IT environment, it is a logical mechanism independent of it.
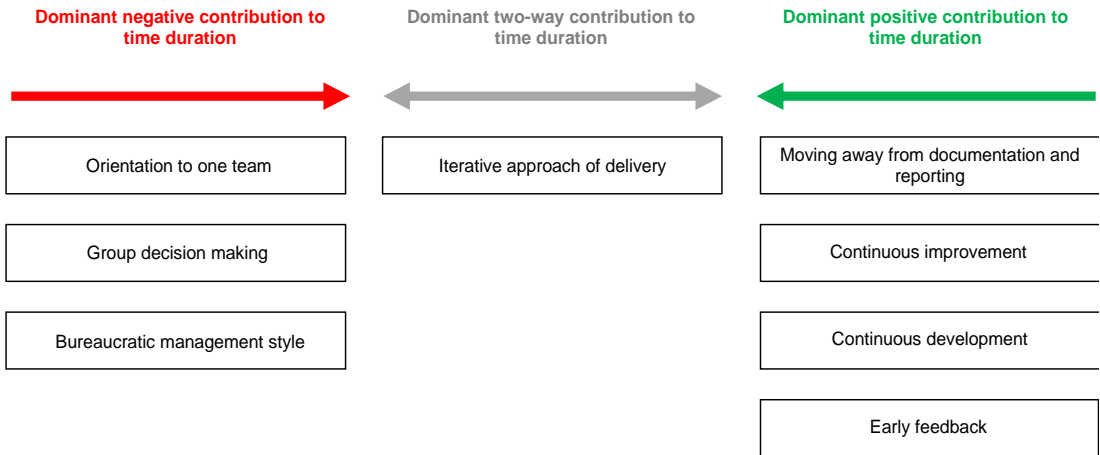

Figure 1. Time tendencies of Scrum practices

3.5. Assessing the Quality of the Studies

The following conclusions can be drawn by focusing on and assessing the quality of publications in this area. Contrary to the expectation that the topic would be problematic to

quantify, and qualitative research would prevail, in summary the quantitative and mixed empirical research dominates with 53%. Nevertheless, the difficulty of quantitatively assessing the speed or effectiveness of a methodology is demonstrated by the fact that the predominant analytical method of quantitative publications is descriptive statistics only. Authors often delegate the responsibility for assessing effectiveness to respondents and merely describe what respondents think. Only 29% of the quantitative papers use correlation mechanisms to arrive at their own conclusions.

Also unsatisfactory are publications that provide insufficient information about respondents which is repetitive pattern. Not only is there a lack of data on the number of respondents to give us an indication of the validity of the outputs, but also a summary of respondent's roles is repeatedly not apparent (Azanha et al., 2017; Ormeño Zender & García De Soto, 2021). This is particularly significant because the role of the responder can have a major impact on biases; for example, one might expect a more positive assessment of the Scrum Master role as the role disappears with the demise of the Scrum methodology. This is reinforced by the aforementioned fact that evaluations about speed and efficiency are often directly transferred from the respondents due to the use of descriptive statistics only.

At the same time, some articles opting for quantitative methods show an insufficiently small sample of respondents for data collection, which repeatedly occurs only in the order of tens (De O. Melo et al., 2013; Hayat et al., 2019). On the other hand, the qualitative research that falls under review in most cases does not describe the analytical methods, which does not allow the reader to discern the degree of working with biases, the degree of interpretation, and the degree of conscious or unconscious focus on sub-topics (Ormeño Zender & García De Soto, 2021; Peixoto & Silva, 2009).

4. Discussion

4.1. Summary of the Main Findings

The literature focusing on Scrum and its contributions to project or initiative timelines can be misleading because Scrum's widely repeated speed is not always supported by empirical evidence of shortening the project or initiative time but is an expression of the flexibility of the framework, not always the ability to deliver a project or initiative in a shorter time.

As discussed in the Results, some elements of Scrum contribute to higher delivery speeds and some to higher time spent. These findings may lead practitioners to follow the ongoing trend of implementing hybrid methods (Reiff & Schlegel, 2022) and choose only from positively contributing practices. If the goal of the enterprise is to maximize delivery speed, it makes sense to construct a framework that will draw only partially from Scrum and can leverage the above description of specific practices to support this goal.

4.2. Reflecting Contemporary Literature

The fact that Scrum contains practices, some of which have a positive effect on project length and some of which have a negative effect, is supported by contemporary trends to

develop hybrid project approaches and typically to select practices from Scrum that make sense in a given context (Hájek & Krupa, 2024).

In line with the findings of this paper, agility and Scrum are credited with the ability to respond flexibly and quickly to changes in the environment, as exemplified by changes in the market. Such a significant number of benefits are repeatedly associated with this agile approach that it makes little sense to unjustifiably glorify it and describe it as the optimal framework for the fastest delivery of change, which even, in its true nature, according to many publications, is not what it seeks to do. This relatively critical view of Scrum's contribution compared to other publications, however, follows the increasing ability of researchers to view agile approaches more distantly, critically and pragmatically (Gregory et al., 2016; Krupa et al., 2023).

4.3. Practical and Theoretical Implications and Proposal

Based on this work, practitioners can better assess whether Scrum is the right choice to reflect the goals of their project or initiative. By assessing the speed aspect at the level of individual practices as well, the paper can also help companies to compose a suitable hybrid framework.

Through a critical subsection on the quality of the publications reviewed, it also seeks to generate pressure for better adherence to methodological standards, which in most cases have been inadequate. The subsection clarifying the time aspects of the publications should also provoke reflection on the accuracy of statements about the positive effects of some of the methodologies that appear to be misleading.

From a scientific point of view, there is an opportunity to verify the claims made in the literature about the positive or negative speed contributions of individual practices and what contribution prevails in a particular context, for example, industry, through quantitative methods.

4.4. Limitations

The limitations of this publication stem primarily from the boundaries of the scope. The review loses some knowledge by focusing only on English publications and publications that are present in the two main publication databases. This has negative implications for the publication bias. Further, as noted, it is limiting to look at impacts only within the flow of a single project or initiative because positive or negative contributions of Scrum are expected to have long-term or delayed manifestations. (Tennant, 2020)

5. Conclusions

An essential consensus among publications is that Scrum provides practices typically leading to improved quality and increased efficiency of change. This, in turn, is redeemed by the time-consuming nature of these practices, creating in sum conflicting forces. These are reflected positively typically in the time-to-market and other time measures. However, when considering the delivery of the maximum amount of change per unit of time, the results are contradictory at the very least, and the resulting positive or negative effect on time spent depends on factors such as the industry of the company in question (Chumpitaz et al., 2020).

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Relationship between Corporate Social Responsibility and Corporate Financial Performance

Adéla ŠRÁMKOVÁ

Czech University of Life Sciences Prague, Prague, Czech Republic; sramkovaad@pef.czu.cz

Abstract: This paper targets the areas of corporate social responsibility and corporate financial performance, more precisely, the topic of their mutual relationship and impact. The goal of this paper is to provide a critical review of the seven selected research studies that already examined the relationship. This critical review investigates and compares the selected criteria, methodology, research panel, research goals, and results. The critical review involves ranking of the research studies based on the strength of the relationship between corporate social responsibility and corporate financial performance. This paper comes with surprising findings that the studies significantly vary in the results. There are multiple studies that identify the relationship between variables, and simultaneously, other studies come with results that there is no relationship or that there is even a negative relationship. The authors further identified that the results of the reviewed studies are impacted by the selected methodology.

1. Introduction

Organizations in the nowadays modern world are under permanent pressure to behave according to specific patterns and be active in certain areas that are expected from the public. One of the most common examples is naturally participation in activities against global warming, against pollution of the global environment, against poverty in developing countries and against diversity discrimination. Those mentioned areas might have been considered permanent in the last years. On top of that, also temporary areas and issues have been continually occurring where organizations help or at least are expected to help. The temporary issues have two major leading topics from the last years. The first one was the global COVID-19 pandemic, where many organizations committed to helping with the fight against the virus; this help had a vast number of forms – e.g., financial support to medical research, financial support to poor people who were affected by COVID-19, free-of-charge consultancy support to non-profit organizations, purchasing of medical equipment and many other forms of support. The second temporary issue has been the Russian – Ukraine military conflict in Europe, where organizations helped affected families who lost their homes. This help was especially through financial donations or through the support of people who emigrated to foreign countries. Such a focus also on these public commitments is also visible in the mindset of millennial investors, for whom is the companies' CSR crucial.

Compared to the older generations, Gen-X considers the CSR about 14% less important, and compared to the generation Boomers, CSR is even 25% less important (AFLAC, 2019). Generation Z is the most conscious generation in the view of CSR (Uche, 2018). Since this generation involve population which is around 20 years old, it can also be an important factor for the employee to attract this generation as a potential employer. From this is evidence that CSR is more important for the younger generation than the older.

Fulfillment and presentation of those public commitments are essential to organizations also from the business perspective. The example of being attractive to younger investors, and thus to future investors, was already mentioned. However, there are many other business reasons that the organizations are aware of. One exemplary business reason is that investors might ask organizations (especially start-ups) about their current and planned commitments. Another example is banking loans, where banks might analyze the behavior of organizations, especially in the relevance to the protection of the environment (e.g. decreasing the level of carbon footprint). The last example is that some organizations already put the public commitments and protection of the environment as one criterion to the selection process when they search for a provider of certain services or products.

The entire area of the above-described commitments that increase public well-being has its naming and is generally referenced as Corporate Social Responsibility (CSR). CSR is a more and more popular and important topic these days and an increasing number of companies accept these commitments (Sharma & Kiran, 2013). There is, however, an unanswered question whether the CSR activities are only to improve their public perception towards the organization or whether the activities are meant seriously to increase the level of the public well-being.

The term corporate social responsibility does not have one official definition; the reason is that CSR is voluntary and not legally enforceable but can be already consider as a sign of a moder company or institution. Notwithstanding the voluntariness, the importance of CSR is increasing and the number of companies, that applies it is significant. Corporate social responsibility is generally a voluntarily accepted company's commitment to behave responsibly regarding the environment, society, and economy (Fatima & Elbanna, 2023). The topic is current and resonates in both academic as well as business areas.

The concept of the CSR is not, however, a subject only of the last years. From the historical perspective, there can be seen related attitudes already in the 18th century by Adam Smith and his concept of the invisible hand, which mention (Wan-Jan, 2006) in his article: *"Smith argued that the metaphorical 'hand' helps produce benefits to society even when the capitalists did not plan for such social benefits. The invisible hand produces outcomes that may not be consciously planned."* The CSR topic has been developed more deeply since 1970s (Trnková, 2004). The CSR topic has been changing during the times as it has always targeted to reflect the current needs and challenges. The actuality of the topic is also proven by numbers of scientific articles which research this topic from many different perspectives.

As is obvious from the previous paragraphs, corporate social responsibility is significantly broad area which might be divided into several dimensions (subareas). The traditional attitude to the CRS involves three primary dimensions (Economic, Social, and

Environment) which were presented and described in many publications, such as (Carson, 1993), (Wan-Jan, 2006) or (Trnková, 2004). Since the term CSR has been widely researched and also leveraged by organizations in many context, many additional dimensions has occurred (Matten & Moon, 2008). The exemplary extension of the traditional approach involves the dimensions of Stakeholder and Voluntariness (Dahlsrud, 2008). Another approach includes in total nine dimensions, which are Charitable contributions, Corporate policies, Environmental performance, Revealed misdeeds, Transparency, Self-reported social performance, Observer's perceptions, Third-party audits, and Screened mutual funds (Hernandez, 2022). This comprehensive approach with nine dimensions can be, however, easily mapped to the traditional three dimensions as follows (Table 1):

Table 1. Extended CSR approach

Original CSR approach	Extended CSR approach
Economic	Third-party audits
	Screened mutual funds
	Transparency
Social	Charitable contributions
	Corporate policies
	Revealed misdeeds
	Self-reported social performance
	Observer's perceptions
Environment	Environmental performance

Table 1 provides evidence that the original dimensions might be efficiently extended to ensure reflection of the current necessities of nowadays. Similarly, (Sharma & Kiran, 2013) adopted the original model and transformed that into the dimensions of, Education, Health and Environment. Subsequently the intersection of all three dimensions is philanthropy. The intersection of education and health is economic responsibility, intersection of health and environment is ethical responsibility and environment, and education is legal responsibility (Sharma & Kiran, 2013).

Based on the introduced CSR models, it is visible that CSR model can be easily modified to the needs of merely any related topic. This also shows that the models, eventually the needs, has been evolving during the time as new areas of the public interest has been coming. Such an evolution brings, nevertheless, a space for misinterpretations and not precise usage of previously defined models and approaches. Thus, it is more than ever crucial to critically examine the researched results before we considered them as granted and correct.

The goal of this paper is to perform critical review of already published scientific articles and proceedings which presented research studies focused on relation of corporate social responsibilities and the financial performance of organizations. The critical review will focus on identification of the common patterns and the differences among the selected research studies.

2. Methodology

The author dealt with the topic of the relationship and mutual impact between the corporate social responsibility and the corporate financial performance. The first step was the

exploring the theoretical foundations of the corporate social responsibility and corporate financial performance. The initial step was followed by identifying the relevant studies, that deal with the related topic.

The author searched for the research studies through Czech National Library of Technology which is connected to 104 electronic resources, such as Scopus, Web of Science, ProQuest Central, ScienceDirect or Taylor & Francis Online. In the bullets below are shown the searches within this library along with the number of results. The search was limited to the types of the publications: Scholarly & Peer-Reviewed, Peer-Reviewed. The critical review research was conducted between May and July 2023.

Searches were conducted using a variety of phrases, including synonyms and related terms, to capture the breadth of literature on the relationship between corporate social responsibility (CSR) and corporate financial performance (CFP). The structure of the bullets is [searched phase] – [number of results]:

- relation between "corporate social responsibility" and "corporate financial performance" – 377;
- relationship between "corporate social responsibility" and "corporate financial performance" – 554;
- mutual impact of "corporate social responsibility" and "corporate financial performance" – 431;
- impact of "corporate social responsibility" and "corporate financial performance" – 527;
- "corporate social responsibility and corporate financial performance" – 17;
- "relation between corporate social responsibility and corporate financial performance" – 1;
- "relationship between corporate social responsibility and corporate financial performance" – 11;
- "relation between CSR and CFP" – 1;
- "relationship between CSR and CFP" – 18.

Initial screening involved reviewing titles and abstracts to identify potentially relevant articles. Articles were included in case they examined the relationship between CSR and CFP, irrespective of industry or geographical location. Because of the fact that only articles published in scholarly and peer-reviewed journals were considered, as was already mentioned, high standard of research papers was ensured. After the initial screening, full-text review was then conducted on selected papers to assess the eligibility of articles based on predefined inclusion criteria.

The final selection of articles was based on their collective ability to address the research question effectively and contribute valuable insights to the understanding of the CSR-CFP relationship. Articles were chosen for their methodological robustness, clarity of findings, and relevance to the research objectives. In total, seven related studies were identified and reviewed within this study.

The researched papers were then analyzed in the following areas: Research target, Research sample, Research period, Methodology and Result of studies. Results within each area are described in the following chapter in dedicated sections.

3. Results

The initial step of the author was a deep analysis of papers (articles, proceedings) that have been published and that focus on the topic of CSR in the relation to the financial performance of organizations. The process of gathering the related studies is described in the section above. After gathering of all relevant papers, the author identifies the ones that directly address the topic and where the real research was performed (not only theoretical consideration). The final list includes seven papers which were published between years 2015 and 2022 and come from an international environment. The list of the selected papers is attached below:

- Research 1 (label: R1): Relationships between Corporate Social Responsibility and Financial Performance: What is the Causality? (Hirigoyen & Poulain-Rehm, 2015)
- Research 2 (label: R2): The relationship between corporate social responsibility and corporate financial performance: Evidence from a developing country (Hossain et al., 2015)
- Research 3 (label: R3): Relationships between corporate financial performance and corporate social responsibility when controlling for socially and environmentally conscious investments (Hernandez, 2022)
- Research 4 (label: R4): Corporate Social Responsibility and Business Performance in Takaful Agencies: The Moderating Role of Objective Environment (Nazri et al., 2020)
- Research 5 (label: R5): Corporate social responsibility and company performance (Adeneye & Ahmed, 2015)
- Research 6 (label: R6): Corporate Social Responsibility And Business Performance: The Role Of Mexican SMES (Guzman et al., 2016)
- Research 7 (label: R7): The causality direction of the corporate social responsibility – Corporate financial performance Nexus: Application of Panel Vector Autoregression approach (Lin et al., 2019)

During the analysis of the selected papers, the author identified five criteria on which this critical review focuses: research target, research sample, period of the research, used methodology and findings of the research. The following sections are split according to the above-listed criteria.

3.1. Research Target

Reviewing the set of hypothesis and research questions was identified that all the studies have the identical main target which can be generalized and defined as to examine whether there is a relationship between corporate social responsibility and corporate financial performance (CFP). Since being aware of this relationship (with potentially both positive and negative results) is crucial for proper governing of companies, I consider it as sufficient research target which is important to deal with. What the author of this review sees as a potential question mark even before the analysis of R1-R7 is whether the studies will be sufficiently predicative to ensure generalization of the results. The overview of the targets of the research is attached in Table 2.

The targets within this table are adjusted (in the way of words formulation and words selection while keeping their origin meaning) for more suitable comparison between themselves. Some of the origin researched targets included specification of the location of examined companies. This information is reviewed in the following section Research sample.

Table 2. Research target

Research	Research target
R1	Examine the relationships between the various dimensions of CSR (human resources, human rights in the workplace, societal commitment, respect for the environment, market behaviour and governance) and financial performance (return on equity, return on assets, market to book ratio)
R2	Examine the relationship between CSR and corporate financial performance (CFP) in a developing country context
R3	Examine the relationship between CFP and CSR including controlling for socially conscious investments and controlling for environmentally conscious investments.
R4	Examine how the dimensions of objective environment influence the relationship between CSR dimensions and the business performance
R5	Examine the impact of CSR on company performance
R6	Examine the existing relationship between CSR and business performance
R7	Examine the relationship between CSR and CFP

3.2. Research Sample

Reviewed studies vary in the used panel data from the minimum of 100 companies (participants/objects of the research) to the maximum of 500 companies where the average number of the companies across the examined studies is 258.

The first perception might indicate that the study with the least participants (100 companies) contained insufficient number of participants. The author of this paper considers this perception, however, as misleading since these companies are considered as the Fortune Most Admired Companies. The Fortune is the magazine which publishes every year the list of the 500 largest United Stated companies by the return (Moles & Terry, 2005). This means that the author of the study analysed only companies that are significantly large. Nevertheless, I would still recommend the authors to extend the research to the remaining 400 companies to get the full picture on the Fortune 500 companies. Another suitable extension of the original study is also to compare the relation between CSR and the financial performance among more years.

Table 3. Research sample

Research	Research sample
R1	329 companies in three geographical areas (the United States, Europe and the Asia-Pacific region)
R2	131 companies
R3	138 companies in the United States
R4	211 managers operating businesses in Kuala Lumpur, Putrajaya, and Selangor state
R5	500 companies in the United Kingdom
R6	397 Small and medium-sized enterprises (SMEs)
R7	100 of the Fortune Most Admired Companies

Regarding the number of participants in the study, the author of this paper highlights that the bigger sample research does not mean better research as it is pointed out also in the article with header *"Bigger isn't always better"* (Anderson & Glebova, 2022). The authors of this publication emphasized the current trend to conduct bigger research samples nowadays. Moreover, they also discussed that it is not possible to set an exact number of the research sample as a sufficient. It varies with each research topic and case, as was also highlighted in (Trotter, 2012): *"Referral sampling (snowball sampling is the most common label) starts with an index individual who is identified as having the key characteristics required by the research design and asking that individual to nominate others with similar characteristics"*.

The overview of research samples of studies R1-R7 is presented in Table 3 above.

3.3. Period

Research period is important indicator which denotes the topicality of the research. The period is one of the fundamental information that describes the research studies. The second date that is linked with the research studies is then the date of its publication which usually differs. From the reviewed research studies, only three of them mention the research period within the description of the research. At the remaining four research studies, no information about the period of the performed research is included. Since the period of the research is one of the main information that should always be published along presentation of the results, this finding brings a question that is impossible, however, to answer – did the authors only forget, eventually disregard, publishing of the period or was it done on purpose not to reveal some suspicious information about the research (e.g. inadequately long or short research period)? For the purpose of this paper, the missing periods were replaced by the year of the research publication as is visible in Table 4.

Table 4. Research period

Research	Research period
R1	2009–2010
R2	2008–2012
R3	2022 (publish date)
R4	2020 (publish date)
R5	2015 (publish date)
R6	2016 (publish date)
R7	2007–2016

3.4. Methodology

During the detailed analyses of the research studies, the author of this paper identified that the methodology among them significantly varies. The highest number of applied research methods was in R5, in total of seven different methods. On the opposite, the lowest number of applied methods was in R6 where only one research method was applied. Using only one research method can be in some cases consider as non-sufficient since the combination of more research methods increases the robustness of the results (Esteves & Pastor, 2004).

Focusing to the examined studies, the majority of them used the multiresearch methods approach. The authors of this paper appreciate this approach since the usage of multiple research methods causes further results verification. From the perspective of the particular methods, regression analysis was applied in 2 research studies (R1 and R5), as well as correlation analysis that was used by also in 2 studies (R3 and R5). The last research method that was applied in more than one research studies was stakeholder theory (R2 and R4). Remaining research methods were applied only in single research studies. This can prove that authors aim to apply their own and original attitude to the methodology, which is consider as a positive finding.

The entire overview of applied methods is presented in Table 5.

Table 5. Methodology

Research	Applied methodology
R1	Linear regression analysis
	Granger causality test
R2	Legitimacy theory
	Stakeholder theory
	Tobin's Q
R3	Non-experimental quantitative correlational study
	Quantitative correlational analysis
R4	Stakeholder and contingency theory
	Questionnaires
R5	Descriptive research
	CSR index
	Market to book value (MBV), company size, and return on capital employed (ROCE)
	Descriptive statistics, regression and correlation analysis
R6	Empirical study
R7	Panel Vector Autoregression (Panel VAR)
	Generalised Method of Moments (GMM)

The authors of the published studies (R1-R7) leveraged many different types of data as part of their research. For the purpose of financial performance analysis, the authors worked with annual reports, indicators such as return on assets, return on equity, market to book ratio, stock market indicator and many others. From the perspective of CSR, the exemplary variables with which the authors operated were human resources and rights in the workplace, corporate governance and market behaviour. In general, the CSR data was less tangible and specific since many times the CSR variables were hard to express mathematically in comparison to the financial data.

3.5. Results of Studies

The findings of the research studies show that there is an inconsistence between their results. After detailed analysis of all seven research studies, the author of this paper identified that the relation between CSR and financial performance is only at four studies out of the seven examined. The remaining three studies show the exact opposite and that is that there is no relation between the two areas.

The following paragraphs provides readers with comparison of the examined studies in terms of strength of the results. The research studies are compared and linked with a value on a scale 1-7 which determines the order of the dependency of CSR to the financial results. Precisely, the value 1 indicates the weakest relation and the 7 the most significant relation. The following scheme graphically demonstrates the order of the research studies in the meaning of the strength of the relation between the CSR and the financial performance (from the highest strength to the lowest).

Figure 1. Comparison of the examined studies in terms of strength of the results

The schema presented above, the order of the relation strength, does not regard whether the relation is positive or negative based on the bias that the impact should be positive in this case. The study R7, however, identified that CSR negatively impacts financial results. I deem this result as significantly surprising since the CSR activities are considered mostly by economic stable and efficient companies (Newman et al., 2020). Even the definition of CSR and related concepts, as is introduced above in this paper, regards CSR as an attitude with the positive effect on the company.

The remaining studies then operate only with the positive relation. The biggest positive relation between the CSR and CFP is noticed by R6, which come to the results the CSR impacts CFP. This is followed by R4 that also considers these two variables impacting themselves positively. The R4 and R6, however, do not specify the concrete indicators, which are used under CFP. This finding is considered as significant since there are plenty of CFP indicators and each evaluate a different aspect. The last study with positive relation between CSR and CFP is R2, which comes to the strong relation but just in the selected indicators. The following R5 and R3 are associated with the moderate relation since both studies find by

Table 6. Findings

Research	Result	Scale	Findings details
R1	No relation	1	No relation – higher CSR activities does not result in improved CFP (return on equity, return on assets, market to book ratio)
R2	Strong relation only at selected indicators	5	Strong relation – positive and strong relation between CSR and CFP (accounting measures of return on assets and equity) No relation – between CSR and CFP considering market
R3	Moderate	3	Moderate relation – CSR does not always result in higher CFP (profit)
R4	Strong relation	6	Strong relation – CSR activities influences CFP directly (overall business performance)
R5	Strong relation	4	Strong relation – CSR activities influences CFP (market to book value and return on capital employed)
R6	Strong relation	7	Strong relation –strong relation between CSR activities and CFP (overall business performance)
R7	No relation	2	No relation – better CSR activities do not lead to better CFP (return on equity, return on assets, and return on invested capital) Relation – higher CFP results lead to higher CSR activities.

some of the indicators just a moderate relation. The authors of the study R1, identified within his research no relation between CSR and CFP.

The overview of the results identified in each research study is presented in Table 6.

4. Discussion

Nowadays organizations devote significant amount of money and effort to corporate social responsibility activities. Some organizations approach the topic seriously, nevertheless, some of them might consider that only as effective marketing means to publicly promote their CSR activities. Since the topic is very current, a vast quantity of studies that research the CSR topic from many perspectives have been performed and published. A significant number of studies touched the question of the relation between organizations' CSR activities and their financial performance. This paper is dedicated to performing critical review of those studies. As a part of the initial research, the author of this paper identified seven highly relevant studies which all focus on the relations between CSR and financial performance. The aim of this paper is to critically review the selected studies with the special focus on the common and different approaches and attitudes.

The most surprising finding is the difference between the studies' results where some studies came to the results that there is a relation between the CSR and the financial performance whereas the authors of the others identified that there is actually no relation or even negative relation between these two variables. The results are definitely impacted by the applied research methods which vary among the reviewed studies. Nevertheless, even using the same research methods can come to the different findings, as show the R1 and R5. Another finding identified during the review was that the authors of the studies are unique in their own attitude to the methodology. There is a question that actually does not involve one correct answer whether usage of such different methods for the determination of the relationship is positive or negative.

The author of this paper sees the significant contribution in research of current studies that occupied the topic of relation between CSR and financial performance, their comparison and especially highlighting the variance of different results of the studies. This variance, which is naturally associated with the fact that this entire topic is wide, is the main reason why this relation of CSR and financial performance of companies should be analyzed even further.

The critical review presented in this paper might be extended in multiple directions since it focused on the initial overall review and analysis of the published research studies without any deep focus on particular areas. Exactly those areas, such as detailed comparison of leveraged methods, leveraged CSR and financial data, exact strength of the relationship between CSR and financial data, differences in the results in relation to particular regions, represent topics for future exploration and thus topics for subsequent research papers.

Conflict of interest: none.

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Mapping the Cultural and Creative Industry in the South Bohemia Region

Růžena ŠTEMBERKOVÁ[1], Miroslava VLČKOVÁ[1], Monika MAŘÍKOVÁ[1], Jan FIALA[1], Michal HOJDEKR[1] and Petra MAREŠOVÁ[2]*

[1] University of South Bohemia, České Budějovice, Czech Republic; rstemberkova@jcu.cz; mvlckova02@ef.jcu.cz; marikova@ef.jcu.cz; hojdekr@jcu.cz

[2] University of Hradec Králové, Hradec Králové, Czech Republic; petra.maresova@uhk.cz

* Corresponding author: petra.maresova@uhk.cz

Abstract: This article aims to facilitate the establishment and coordination of an integrated network comprising current stakeholders in the cultural and creative sector, along with key entities in tourism. Fostering the growth of the creative sector within distinct regions plays a pivotal role in establishing a robust framework for planning, collaboration, and enhancing the efficacy of generating additional impacts within the cultural and creative industries. The focus is particularly on the South Bohemia Region and the adjacent border region encompassing the territory of the South Bohemia Region and Lower Bavaria. The objective is to bolster the development of a comprehensive system that encourages synergy among cultural and creative entities, contributing to the overall advancement and efficiency of the region's cultural and creative industries, while concurrently fortifying ties with significant tourism stakeholders.

Keywords: creative industry; creative index; mapping; South Bohemia; Lower Bavaria

JEL Classification: R50; R58

1. Introduction

The National Research and Innovation Strategy for Intelligent Specialisation of the Czech Republic 2021-2027 (hereinafter "National RIS3 Strategy") ensures effective targeting of European, national and regional resources to support oriented and applied research and innovation. The National RIS3 Strategy directs support to selected priority areas that have a high potential for creating a long-term competitive advantage of the Czech Republic based on knowledge exploitation and innovation (for thematic areas see Figure 1). The identification and development of these promising areas, i.e. "smart specialisation", builds on the strengths of the Czech Republic and individual regions. It seeks to make targeted "smart" use of the unique combination of opportunities offered by our economic base and research and innovation capacities. At the same time, the strategy identifies and addresses weaknesses in the innovation system that ultimately represent barriers to the development of smart specialisation and the innovation environment as a whole.

These weaknesses are summarised in the analytical part of the National RIS3 Strategy, which is based on a wide range of background analyses. The analysis identifies low value added and a focus on lower-order innovations as a significant general problem of the Czech

economy compared to advanced economies, which, on the contrary, focus on knowledge-intensive activities. This is largely due to the type of manufacturing activity prevalent in the Czech Republic, which is located in the lower tiers of value chains. Moreover, the Czech Republic has a weak endogenous business sector and, despite its industrial tradition, technical competence and creativity of its population, does not have a broader base of technologically advanced firms located in the higher tiers of global value chains. Moreover, instead of diversifying the country's product base, it is concentrated in a few sectors, which increases the vulnerability of the whole economy in the event of external shocks.

The development of the economy towards higher innovation and added value is also hampered by a lack of qualified people and the absence of a stable, predictable and motivating business environment. A functioning public R&D system producing quality results can make a significant contribution to the development of an economy based on knowledge, added value and the ability to respond to current technological and societal trends. Despite the significant potential of some domestic research organisations and infrastructures, the overall quality and performance of public R&D in the Czech Republic still has reserves. A key issue in terms of RIS3 is also the insufficient exploitation of public R&D results for the needs of companies and society.
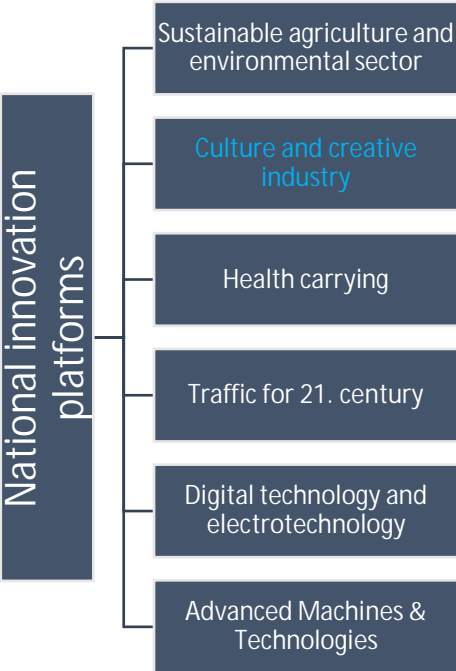

Figure 1. Thematic areas/National Innovation Platforms and domains of specialization (Hartley, 2004)

It should be noted that the Cultural and Creative Industries thematic area has two application sectors – Traditional Cultural and Creative Industries (Traditional Industries for short) and New Cultural and Creative Industries (New Industries) (Table 1).

R&D expenditures in the business sector are relatively high in both application sectors and continue to increase. R&D expenditure is particularly high in the application sector Traditional Industries. Both SMEs and large enterprises are involved in R&D here, but more than half of the R&D expenditure takes place in foreign-controlled enterprises. Research-

active enterprises are active in all regions of the Czech Republic, with the highest R&D expenditure in Prague and the Central Bohemia and Zlín regions. The concentration of R&D expenditure is not very high.

Table 1. Traditional/new cultural and creative industries (Hartley, 2004)

Traditional cultural and creative industries	Fine Art Theatre Music Dance Literature Museums Design Architecture
New cultural and creative industries	Animation Film Media Television and radio Advertisement Digital platforms Intermedia Computer games

It is expected to be complemented by other areas such as the development of advanced materials and technologies and their use in a range of areas, including traditional craft techniques, art, design, heritage conservation and other cultural and creative professions and possibly others including the use of natural, renewable and recycled materials, reducing environmental impact; the development of digital technologies (including ICT and artificial intelligence) and their wider use in all areas, including media production, performing arts, architecture, archiving, librarianship and other cultural and creative industries; open access to data, databases and other information.

2. Methodology

In the context of the growing importance of the creative economy, there is a growing need for statistical coverage of the output of the creative sector, which is then linked to efforts to quantify the impact of this sector on the economy of individual countries and regions. However, this is an area that is not uniform and where there are no well-defined and used definitions of terms. There are different definitions at different levels. However, definitions sometimes leave some room for interpretation.

The American economist Solow (1957) published a study on the impact of technology on economic growth. Lucas (1988) and Glaeser (1995; 1998; 1999; 2000) also discuss the impact of human capital on the economy. The relationship between the educational attainment of the population and economic growth is discussed by Barro (2001).

Florida and Tinagli (2004) identified three types of creative activity: technological/innovative, economic and artistic. These three types of creativity are interrelated, interdependent and complementary. They are key to the emergence and development of creativity in the economy. Florida himself stated, "Creativity, whether

cultural, scientific, civic, technological, or social, etc., is the driving force of the modern global economy." Urban regions are key laboratories where this process takes place and where all types intersect.

Existing tools according Jeřábek (1993) used to capture and assess the economic performance of different sectors of the economy are not suitable for our two-pronged approach, but are in principle based on them. Current statistical tools do not allow for an assessment of the creative industries and the creative economy. At European and national level, the statistical categories are often too broad, making the data collected incomparable. According to Hartley (2004), the problem with the definition of a creative area, creative economy, creative sector, etc. and the subsequent statistical investigations can be seen in how creative industries differ from traditional industries. This is primarily the inability to fit the creative industries into the chain of traditional definitions, primary, secondary and tertiary sectors. The products of the creative economy can be found in each of these sectors. It is problematic to identify the creative industries on the basis of the output of the product, as is the case in traditional industries such as the automotive industry, the steel industry, etc., because creativity is an input, not an output (Surynek, 2001).

The creativity index (CI) is an indicator that can be used to calculate and measure creativity and its development in different geographical areas. The creativity index is based on research by Richard Florida, who uses the so-called 3Ts of creativity, which stands for talent, technology and tolerance. He explains this theory by saying that creative people prefer places that are different, tolerant and open to new things and ideas. Each of the 3T indices is composed of other sub-indices and has different measurement parameters (Figure 2).
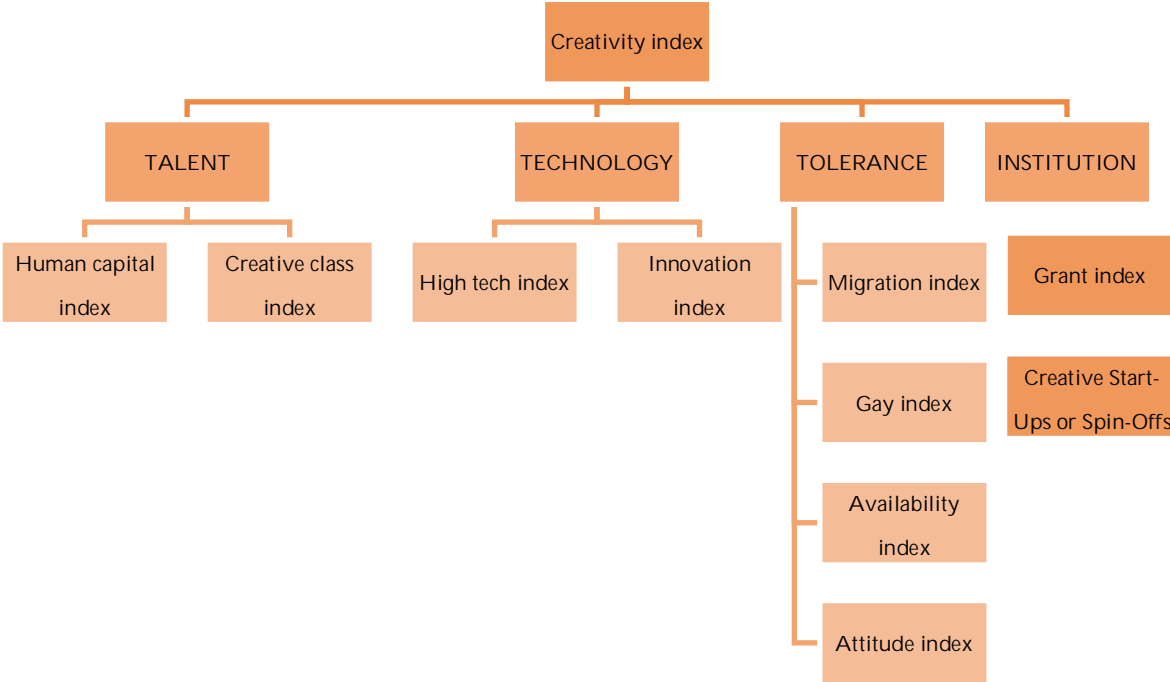

Figure 2. Creativity index (own processing based on Florida and Tinagli (2004))

435

The 3T creativity index has been adapted for Europe in the form of a Eurocreativity index, which consists of three sub-indices: the Eurotalent index, the Eurotechnology index and the Eurotolerance index. Similarly, the 3T creativity index – tolerance, technology and talent – was constructed for each of the 14 regions of the Czech Republic (Kloudová, 2009).

Naylor and Florida (2003) introduced a new framework for measuring the creative economy. In this work, authors describe the growth of the creative economy and the changing layers of American society in the second half of the 20th century. They emphasize the geographic concentration of creative capital and relativizes the concentration of creative capital, economic growth, and regional development.

For the application of the creativity index Mellander and Florida (2007) to the border region of South Bohemia and Lower Bavaria, we rely on the Florida 3T model, i.e., the model of technology, talent and tolerance. For each of these indices it was necessary to select sub-indices that can be applied to the conditions of the mentioned border areas.

The method of constructing the creativity index consists of the following calculation steps:

1. First, the individual sub-indices are added up, i.e., all the sub-indices of talent, tolerance, technology and institutional for both areas.
2. The next step is to rank the scores of both territories from best to highest.
3. The better county gets 2 points, the other counties get a score proportional to the distance from the best index using a "trinomial".
4. The scores thus allocated for all indices are added together to give us the score for each territorial area.

Measuring the creativity index. In this project, the Florida approach was chosen and the creativity index was based on the so-called 3T model. The 3T's include talent, technology and tolerance. The main rationale for his theory is that creative people choose cities for their lives that are different because they are tolerant and open to new ideas, which leads to a concentration of creative capital in the region. Each 3T indicator is composed of other sub-indicators and has split measurement parameters.

In calculating our creativity index – Culture Creative Index (CCI), sub-indexes of talent, technology, tolerance and institution were determined, while economic performance indicators were also considered (Table 2). It is primarily about capturing the conditions, the environment for the development of creative industries. In the next section, the areas of calculation of the indices and within each area, the individual indicators from which the creativity index is calculated are presented.

However, Florida's approach has been modified to match the temporal evolution and accuracy as well as the availability of data in the survey region. In addition, the approach was adjusted during the bilateral coordination of data availability.

The overall index is the simple sum of the individual sub-indices without any weighting of the individual sub-indices, or the weights are equal. Some sub-indices have a major

Table 2. Structure of the CCI and the importance of each sub-index according to the methodology.
(own processing based on Florida and Tinagli (2004))

SUBINDEX TALENT		
A.	Human Capital Index (HCI) – percentage of people from the South Bohemian Region with higher education to the total population in the South Bohemian Region	
B.	Creative Class Index (ICT) – share of art schools in South Bohemia in the population of South Bohemia	
C.	Technical Information Index (ITJ) – percentage of students studying technical fields and informatics at schools of all types in the population of South Bohemia	
D.	Language index (IJ) – percentage of population in South Bohemia with language education in the population of South Bohemia	
TECHNOLOGY SUBINDEX		
E.	Research and Development Index (RDI) – expenditure on technology as a share of GDP in South Bohemia	
F.	Innovation index (II) – number of granted patents per capita in South Bohemia	
TOLERANCE SUBINDEX		
G.	Migration Index (IM) – share of foreign migrants in the South Bohemia Region in the total population of the South Bohemia Region	
H.	Attitude index (IP) – percentage of tolerant people to the total number of respondents in South Bohemia	
I.	Gay Index (GI) – number of registered partnerships per population in South Bohemia	
INSTITUTIONAL SUBINDEX		
J.	Grant Index (GrI) – share of EU projects per capita in South Bohemia	
K.	index start-up or spin-off (ISU) – number of start-ups or spin-offs per population in South Bohemia	
L.	availability index (ID) – percentage of transport connections in the region per capita in South Bohemia	

Table 3. Calculation of CCI (part 1)

	Period or date to which the data used relate	Subindex value in %
SUBINDEX TALENT		
A. Human Capital Index (HCI) – 58,268 persons aged 15 and over with higher education out of 537,217 persons of this age in South Bohemia, recalculated with respect to 2021 (Český statistický úřad, n.d.)	26. 3. 2021	9.146
B. Creative Class Index (ICT) - 45 art schools in South Bohemia, recalculated with respect to 2021 (Český statistický úřad, n.d.)	30. 6. 2022	0.0071
C. Technical Information Index (ITJ) – 3,705 students and graduates of technical fields and computer science at universities in South Bohemia, recalculated with respect to 2020 (Soukupová, 2022)	School year 2020	0.5757
D. Language index (IJ) - The necessary data are not officially available (CSU), the results of the own questionnaire survey were used, only good and very good knowledge of a foreign language was taken into account, a total of 593 cases, i.e. 67% of 882 all respondents... necessary assumption - the sample is representative (own survey)	2022/2020	67.2335 Only a very rough, rather highly optimistic estimate[1]

Table 3. Calculation of CCI (part 2)

	Period or date to which the data used relate	Subindex value in %
TECHNOLOGY SUBINDEX		
E. Research and Development Index (RDI) - Share of expenditure on R&D in South Bohemia - CZK 3.4 billion, i.e. EUR 136,000,000, recalculated with respect to 2020, (Český statistický úřad, n.d.)	2020	1.2
F. Innovation index (II) - Number of granted patents (granted to companies, public research institutions, public universities and individuals) - 17, recalculated in relation to 2020 (Úřad Průmyslového Vlastnictví, n.d.)	2020	0.00264
TOLERANCE SUBINDEX		
G. Migration Index (IM) – 23,601 foreigners in South Bohemia in 2020[2], recalculated with respect to 2020 (Český statistický úřad, n.d.)	2020	3.6673
H. Attitude index (IP) – The data is not officially available (CSU), the results of our own questionnaire survey were used, only rather high and very high openness towards new futuristic buildings was taken into account, 333 cases in total, i.e., 37.755% of 882 all respondents... necessary assumption - the sample is representative (own survey)	2022	37.7551 Only a very rough, rather highly optimistic estimate[3]
I. Gay Index (GI) – Number of couples in registered partnerships in South Bohemia - 209, recalculated with respect to 2021 (Český statistický úřad, n.d.)	2021	0.032806
INSTITUTIONAL SUBINDEX		
J. Grant Index (GrI) - Number of EU projects in South Bohemia – 2,876, recalculated for 2021 (Kohesio, n.d.)	1. 12. 2021	0.4514
K. index startup or spin-off (ISU) - Number of supported start-ups in 2021 - 3, recalculated in relation to 2021 (Jihočeská Univerzita v Českých Budějovicích, n.d.)	2021	0.000471
L. availability index (ID) (Jikord, n.d.)	2022	0.958741
CCI VALUE AFTER ROUNDING TO HUNDREDS		121.03

[1]The estimate would mean that about 67% of the entire population in the South Bohemian Region speaks one or more foreign languages well or very well. The value is probably strongly influenced by the more than half of the respondents aged 18-24.

[2]The data used take into account the migration wave associated with the war in Ukraine.

[3]The estimate would mean that about 37.755% of the entire population in the South Bohemian Region has a high or very high degree of friendliness towards new futuristic buildings. The value is probably greatly influenced by more than half of the respondents being aged 18-24.

impact on the overall value, others have a minimal impact. In my view, comparisons of scores that take more account of how a region is moving towards or away from another region for a given sub-index are more relevant to the overall assessment.

3. Results

The cultural and creative industry is a highly structurally complex sector of the economy, and it is not easy to capture its development statistically; it is still in a state of development. One possibility is to calculate the CCI.

The aim is to determine the current value of the CCI for the South Bohemia Region.

The calculated CCI will apply to the South Bohemia Region with all its districts: České Budějovice, Český Krumlov, Jindřichův Hradec, Písek, Prachatice, Strakonice, Tábor.

For each sub-index, the source of the data is indicated, as well as the period or date to which the data used relate (Table 3).

Population of the South Bohemia Region as of 31 December 2020 – 643,551.

Population of the South Bohemia Region 26 March 2021 – 637,085.

4. Conclusions

In terms of evaluating the calculation of the CCI index and comparing it to Lower Bavaria, where the CCI index was prepared using the same methodology, we can state that both areas have comparable ILK, ICT, IJ and GI sub-indices. On the other hand, there are significant differences in the ITJ, IVV, II, IM, IP, GRI, ISU and ID indices. In addition to that, we can conclude the following:

a) The higher value of the technical-information sub-index (ITJ) in favour of Lower Bavaria confirms the higher percentage of students studying technical disciplines and computer science in schools of all types per population than in South Bohemia.

b) Technology expenditure as a share of GDP (IVV sub-index) is lower in South Bohemia than in Lower Bavaria.

c) The number of granted patents (sub-index II) per capita is higher in Lower Bavaria than in South Bohemia.

d) The Migration Index (IM) showed a higher proportion of migrants in the population in Lower Bavaria than in South Bohemia. The values of the sub-indices in both cases are strongly influenced by the migration wave caused by the war in Ukraine.

e) The percentage of tolerant people to the total number of respondents in South Bohemia (IP) can be considered as a more valid result (estimate) than the value of the same sub-index in the case of Lower Bavaria due to the sufficient number of respondents in the implemented questionnaire survey.

f) The value of the Grant Guarantee Index (GRI) is higher in South Bohemia than in Lower Bavaria (this is a comparison of the number of EU projects, not a comparison of the total amount of grant funding received).

g) Not surprisingly, the value of the sub-index start-up and spin-off is higher in Lower Bavaria than in South Bohemia, which indicates a more developed state of R&D and new technologies and their support.

h) An interesting result was obtained by comparing the accessibility sub-indices; the accessibility by public transport is roughly twice as good in South Bohemia as in Lower Bavaria. It seems that people in South Bohemia rely on transport accessibility much more than in Germany.

It can be summarized that the two geographically and historically close areas are comparable in a number of criteria; for example, both areas have approximately the same population of university-educated people, have a comparable proportion of art schools in

the population, the people of both areas have approximately the same language skills, or show approximately the same level of tolerance towards persons entering into registered partnerships.

On the other hand, the two territories differ considerably in a number of indicators. For example, in Lower Bavaria, more students study technical fields and computer science, and Lower Bavaria invests more in the development of new technologies than South Bohemia, which is also reflected in a higher number of patents granted and a higher value of the sub-index start-up and spin-off. The German region also shows a higher tolerance of attitudes and openness to new futuristic constructions than the South Bohemia region. Given the EU's long-standing support for the development of former European post-communist countries, it is not surprising that the number of projects in South Bohemia is higher per capita than in Lower Bavaria. Probably for historical reasons, we observe a higher availability of public transport on Czech territory than on German territory.

Also, the comparison of the region's scores in the individual sub-indices and the comparison of the total scores shows that South Bohemia is lagging behind the Lower Bavaria region. The significance of these values would increase if all sub-indices were monitored over a long period of time, for example over several years, and it would be possible to model a certain trend and development of both regions in the CCI.

The data for the comparison of the CCIs come mainly from available databases, especially the CSO or the South Bohemia Region and similar institutions on the German side, or were drawn from the results of our own questionnaire survey and its analysis. However, it is the results used from the questionnaire survey that have brought with them (especially on the German side) a considerable bias in the resulting comparison. It is therefore necessary to identify the values on the language skills of the population or the values on tolerance towards migrants, which are affected by the migration wave due to the war in Ukraine, as biased. Finally, it should also be pointed out that, due to the unavailability of data from certain years, recalculations of some sub-indices have been made with respect to years other than those from which the data originated. However, the resulting errors have a rather negligible impact on the resulting CCI value. The comparison of the CCIs for the two areas mentioned above should therefore be considered as indicative only.

Conflict of interest: none.

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Global Trends in Fertilizer Commerce: A Dual Analysis of General and Nitrogen Fertilizer Markets

Karel TOMŠÍK[1]*, Klára BARTOŇOVÁ[1], Jiří MARUŠIAK[1], Michal ČERMÁK[1], Vojtěch BLAŽEK[2], Karel MALEC[1], Mansoor MAITAH[1]

[1] Czech University of Life Sciences Prague, Prague, Czech Republic; tomsikk@pef.czu.cz; bartonovak@pef.czu.cz; marusiak@pef.czu.cz; cermak@pef.czu.cz; maleck@pef.czu.cz; maitah@pef.czu.cz

[2] University of South Bohemia in České Budějovice, České Budějovice, Czech Republic; vblazek@pf.jcu.cz

* Corresponding author: tomsikk@pef.czu.cz

Abstract: This paper explores the dynamics of the global fertilizer market, focusing on general and nitrogenous fertilizers. The aim of the paper is to determine the trends and shifts in this market, specifically examining the role of major players like Russia and Brazil and the growing influence of Middle Eastern countries in nitrogenous fertilizer exports. The study employs index analysis of export and import data over the last 20 years, highlighting the evolution and current state of the market. The results indicate growing trade volumes and evolving trade patterns, reflecting the market's response to global economic and political factors. The discussion includes an emphasis on the increasing global demand for nitrogen fertilizers, which is expected to reach 108 million metric tons by 2024, driven by lower prices and the need for higher agricultural yields. It also highlights the significant role of Middle Eastern countries, especially Oman, in the nitrogenous fertilizer market, leveraging their abundant natural gas resources and strategic locations for expanding exports.

1. Introduction

The global fertilizer market plays a critical role in maintaining agricultural productivity and ensuring food security despite efforts to restrict their use. This market has evolved significantly over the years, with nitrogen fertilizers emerging as a key component. Their importance in modern agriculture cannot be overstated, as they are fundamental to enhancing crop yields, particularly in staple crops like wheat and rice (Kottegoda et al., 2017), which is one of the most produced grains in the world after maize (Statista, 2023). This has been essential in meeting the food demands of nearly half of the world's population (Ceasar, 2018).

Fertilizer markets are also crucial in ensuring the stability and sustainability of food systems, especially in the face of global challenges such as conflicts and supply shocks (Ben Hassen & El Bilali, 2022; Shahini et al., 2022). Ben Hassen and El Bilali (2022) and Shahini et al. (2022) explained that the disruption of fertilizer supplies due to conflicts, as seen in the Russia-Ukraine war, can lead to reduced agricultural productivity and subsequent rises in food prices. Additionally, the excessive and indiscriminate use of chemical fertilizers in

developing countries has been a common practice to intensify crop yield, highlighting the significance of fertilizers in agricultural productivity (Sharma et al., 2022).

Nitrogen fertilizers, in particular, have become increasingly important in global agriculture. Most agricultural production systems are limited by nitrogen availability, hence the widespread and increasing use of nitrogen fertilizers (Irisarri et al., 2021). However, the efficient use of nitrogen fertilizers is crucial for sustainable agriculture, as it can reduce the negative impact of agriculture on the environment (Szulc et al., 2020). Furthermore, nitrogen fertilization can lead to changes in agricultural characteristics and gas emissions, affecting global warming (Park et al., 2023). Therefore, the management and application of nitrogen fertilizers are critical not only for agricultural productivity but also for environmental sustainability. The efficient use of nitrogen in agriculture is a subject of extensive research, focusing on management practices, precision agriculture, and soil tillage strategies (Rütting et al., 2018).

It is important to say that scarcity of fertilizer supplies could lead to significant global repercussions, particularly in developing nations. In these regions, the impact of soaring fertilizer costs could drastically curtail usage, potentially leading to diminished local crop yields during periods of reduced global supply and unprecedentedly high prices. Elevated fertilizer prices contribute to an increase in the cost and a decrease in the abundance of the world's food supply. This occurs as farmers, facing financial constraints, reduce the amount of nutrients provided to their crops, resulting in decreased agricultural yields (RaboResearch, 2022).

Moreover, the global fertilizer market has significant economic implications. The global fertilizer market, particularly the nitrogen fertilizers market, is influenced by various factors such as technological advancements, environmental concerns, and international trade dynamics. Fertilizer production accounts for a substantial portion of ammonia and nitric acid demands, and it has a considerable market size in terms of revenue (Lim et al., 2021). However, the rising international prices of fertilizers, exacerbated by increasing oil and gas prices, pose challenges for governments in subsidizing fertilizers and maintaining food security (Dulanjani & Shantha, 2022; Ward et al., 2020).

One of the key trends in the global fertilizer market is the adoption of knowledge-based nitrogen management practices aimed at increasing staple grain production while minimizing greenhouse gas emissions and reactive nitrogen pollution (Xia et al., 2017). This trend reflects a shift towards sustainable agricultural practices prioritizing productivity and environmental impact.

There are trade-offs between nitrogen fertilizer use and land utilization, emphasizing the need to consider resource efficiency in food production systems (Ibarrola-Rivas & Nonhebel, 2016). This perspective is crucial in understanding the trade dynamics of nitrogen fertilizers, as it reflects the complex relationship between fertilizer use, land availability, and international trade patterns. In the context of international trade, the importance of food supply chain resilience to environmental shocks is emphasized, highlighting the need for diverse sourcing strategies and domestic reserves to mitigate potential disruptions in the global fertilizer market (Davis et al., 2020). Furthermore, the incidence of environmental charges in the nitrogenous fertilizer industry within the context of trade exposure provides insights into the economic and regulatory aspects influencing international trade dynamics (Bushnell & Humber, 2017).

It is compelling to note that the global dependency on nitrogen fertilizers has led to a significant increase in agricultural productivity, contributing to food security. However, recent shifts in trade patterns, coupled with environmental and geopolitical factors, have raised concerns about the stability and sustainability of the global fertilizer market. The interconnectedness of international trade, environmental impacts, and agricultural productivity underscores the need for comprehensive strategies to address the challenges and opportunities within the fertilizer market and nitrogen fertilizer market.

The aim of the paper is to examine trends in the global fertilizer market and to clarify the nuances of the international trade with fertilizers and nitrogenous fertilizers. In particular, the first research question is to identify the main actors in the trade with fertilizers and nitrogen fertilizers. The second research question concerns the investigation of the differences between the general trade with fertilizers and the trade with nitrogenous fertilizers among the largest exporters.

2. Methodology

To identify the global fertilizer market trends, the focus was on the volume of exports and imports expressed in monetary value, specifically in United States Dollars (USD). To compare the tendencies, the index analysis was used as the primary statistical method. The paper uses the growth coefficients, which determine the dynamics of the observed time series. The basis is formed by the simple growth coefficient

$$k_i = \frac{Q_i}{Q_0}, \tag{1}$$

where Q_i represents the value in the current period and Q_0 represents the value in the base period.

Because the simple growth coefficient demonstrates only the change within two periods, the average growth coefficient is also employed. The average growth coefficient, which determines the average growth during the observed period, is calculated as a geometric mean of all simple interannual growth coefficients:

$$\overline{k} = \sqrt[n]{k_1 \cdot k_2 \cdot \ldots \cdot k_n}. \tag{2}$$

By replacing the individual coefficients with the expression from Equation 1, the following formula is achieved:

$$\overline{k} = \sqrt[n]{\frac{Q_1}{Q_0} \cdot \frac{Q_2}{Q_1} \cdot \ldots \cdot \frac{Q_n}{Q_{n-1}}} = \sqrt[n]{\frac{Q_n}{Q_0}}. \tag{3}$$

The average growth coefficient represents one of the primary indexes used to describe a specific time series (Hindls et al., 2007). In this paper, average growth coefficients for the largest exporters will be compared to determine the tendencies among particular countries.

The data employed in this paper were taken from the Trade Map database, an online platform developed by the International Trade Centre UNCTAD/WTO (ITC). The values from the last 20 years were used (International Trade Centre, 2023). The dual analysis of the trends focuses on comparing the general and nitrogenous market development with fertilizers. In both cases, the attention was paid to the five largest exporters.

3. Results

As the global population expands, a demand for higher agricultural yields arises. Simultaneously, the trade volume associated with fertilizers experiences an adequate increase. This tendency is outlined in Figure 1, where the exports of fertilizers expressed in metric tons are presented. Due to the limitation of the International Trade Centre database, which contains only data on trade values in USD, the FAOSTAT database was used for this particular figure (FAOSTAT, 2024).
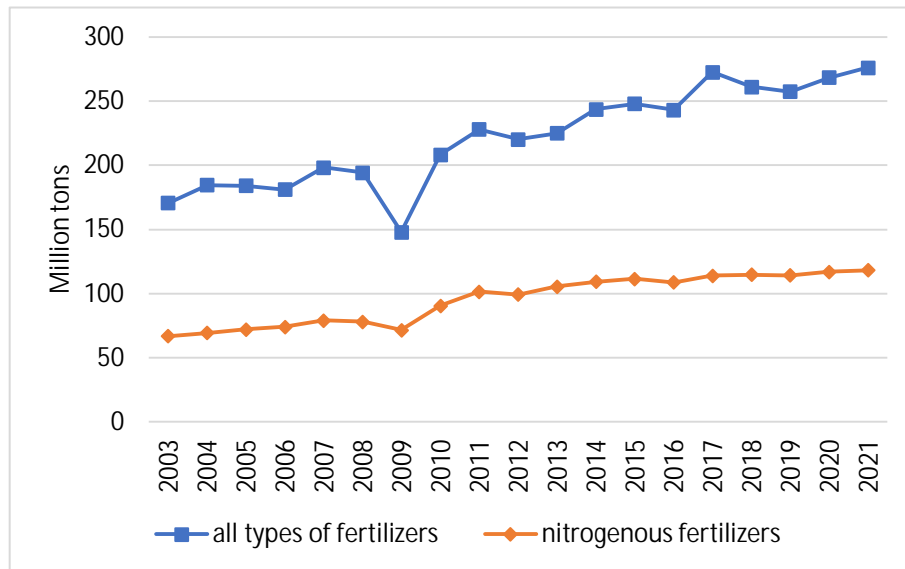

Figure 1. Global exports of fertilizers 2003–2021 in tons (own elaboration based on data from FAOSTAT 2024))
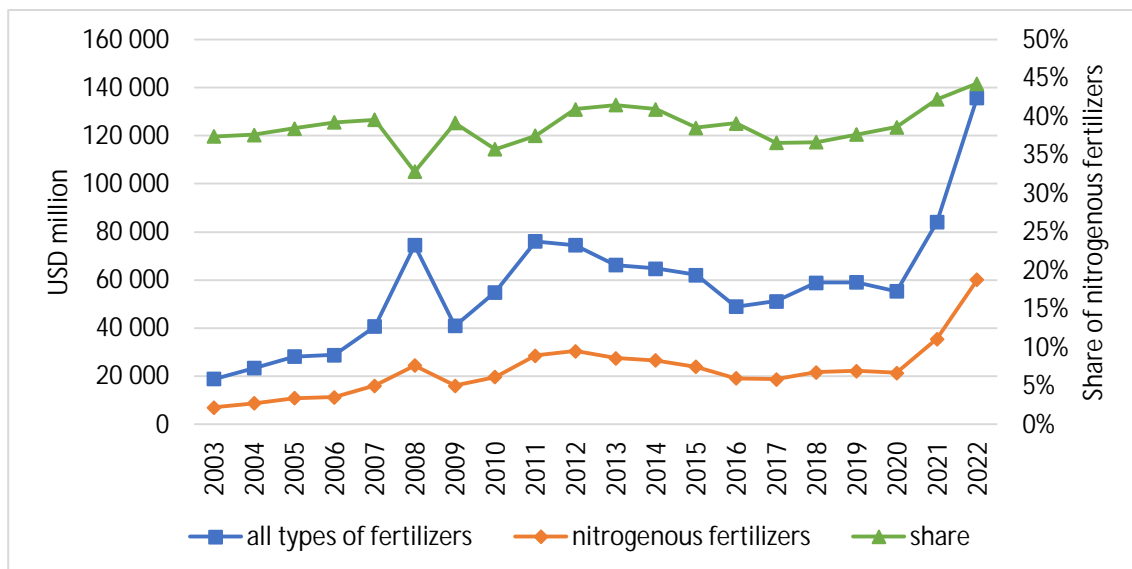
Figure 2. Global exports of fertilizers 2003–2022 (own elaboration based on data from International Trade Centre (2023))

Figure 2 sets up the basic framework for the analysis of the trade with fertilizers. A constant augmentation in the amount of fertilizers exported is intricately linked to the dynamics of changes in the prices of the key commodities needed to produce fertilizers

(Huang et al., 2009). For this reason, it is possible to identify significant volatility in the trade volume expressed in USD.

Before 2008, the prevailing trend in the fertilizer market reported a rise in the value of exports. This tendency resulted from two phenomena: the increasing demand for fertilizers and the escalation in commodity prices. However, the growing prices entailed demand destruction, manifesting as a noticeable reduction in the exported value in 2009 (Huang et al., 2009).

The significance of commodity prices has become evident over the past two years after the outbreak of the Ukraine conflict. Heightened uncertainty and disruptions in the markets of key crops for fertilizers have resulted in a rise in commodity prices. Concurrently, the escalation in fertilizer prices can be attributed to an increase in natural gas prices, as natural gas is necessary for producing fertilizers. The conflict has also shown its influence because of Russia's abundance of natural gas (Kee et al., 2023). While the overarching trend in the general demand for fertilizers has not undergone substantial changes, the monetary value of exports has experienced a considerable increase in the last two years (Quinn, 2020).

Within the dual analysis, it was necessary to delineate the scope of the role of nitrogen fertilizers in the entirety of the fertilizer trade. Based on the examined time series, it is evident that nitrogenous fertilizers establish the predominant constituent within the long-term perspective of fertilizer trade. In recent years, nitrogenous fertilizers have almost attained a half share in the monetary value of the global fertilizer trade. Specifically, the share of individual types of fertilizers in total exports is shown in Figure 3.
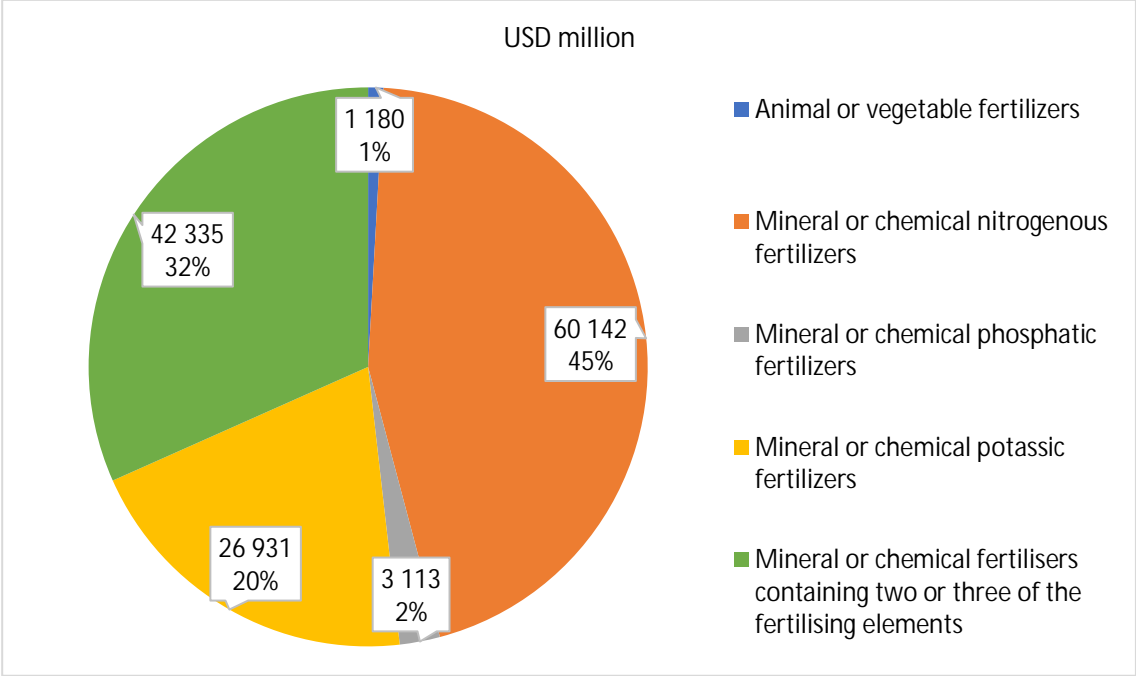

Figure 3. Structure of the global export of fertilizers in 2022 (own elaboration based on data from International Trade Centre (2023))

For the analysis of global trends itself, it was first necessary to identify the main global actors. The following table demonstrates the five largest exporters on the general market with fertilizers and on the market with nitrogenous fertilizers in 2022.

Table 1. Five largest exporters of all types of fertilizers and nitrogenous fertilizers in 2022 (own elaboration based on data from International Trade Centre (2023))

All types of fertilizers			Nitrogenous fertilizers		
Country	Value exported in 2022 (USD million)	Share in world export	Country	Value exported in 2022 (USD million)	Share in world export
Russia	20,969	15.44%	Russia	7,222	12.01%
Canada	13,729	10.11%	Oman	4,976	8.27%
China	11,380	8.38%	China	4,923	8.19%
USA	8,472	6.24%	Qatar	3,577	5.95%
Morocco	7,715	5.68%	Saudi Arabia	3,221	5.36%

In the case of exports, Russia stands as the largest exporter in both categories. Beyond Russia, China also emerges as one of the five major exporters. Nevertheless, it is necessary to highlight that, in contrast to the trade involving all types of fertilizers, the preeminent positions in nitrogenous fertilizer exports are predominantly occupied by Middle Eastern countries.

The same table was created to outline the situation among the main importers. In this case, there is no significant difference between the situation in the import of all types of fertilizers and the import of nitrogenous fertilizers.

Table 2. Five largest importers of all types of fertilizers and nitrogenous fertilizers in 2022 (own elaboration based on data from International Trade Centre (2023))

All types of fertilizers			Nitrogenous fertilizers		
Country	Value imported in 2022 (USD million)	Share in world export	Country	Value imported in 2022 (USD million)	Share in world export
Brazil	24,785	16.17%	India	7,489	11.59%
India	17,260	11.26%	Brazil	6,683	10.34%
USA	13,248	8.64%	USA	4,885	7.56%
China	4,954	3.23%	France	3,581	5.54%
France	4,786	3.12%	Australia	2,323	3.60%

The relationships between the largest exporters and importers were examined as a next step. Among the top five global exporters of all types of fertilizers, Brazil is consistently ranked as the largest or second-largest trading partner. However, within the subset of the top five exporters of nitrogenous fertilizers, Brazil is the primary trading partner solely for China. Meanwhile, Brazil does not belong among the largest trading partners for Qatar and Saudi Arabia.

The last step of the analysis was the usage of growth coefficients. The procedure described in the methodology was applied to the five largest exporters of all fertilizers and, simultaneously, to the five largest exporters of nitrogenous fertilizers. To discern the principal patterns, simple growth coefficients were calculated to determine the changes in the last 20 years, the last 10 years, and the interannual change. Moreover, the average growth coefficient was calculated for the whole period.
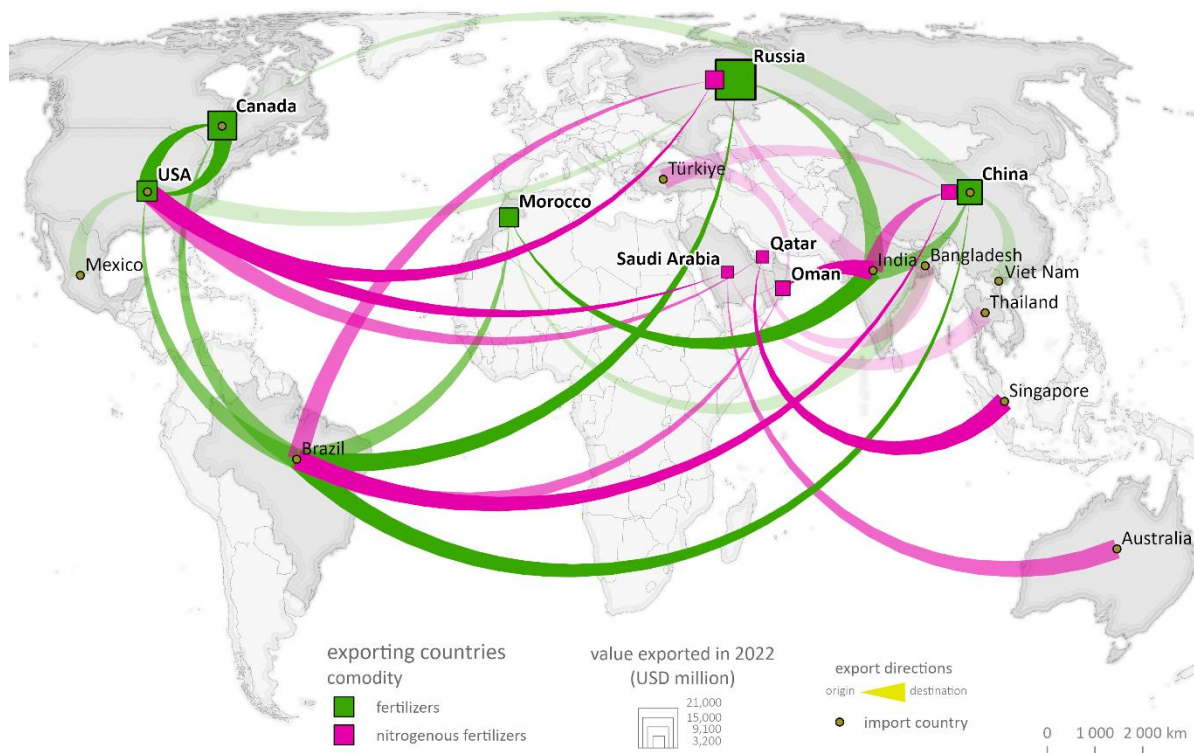
Figure 4. Relations between the largest exporters and importers of all fertilizers and nitrogenous fertilizers (own elaboration based on data from International Trade Centre (2023))

Table 3. Analysis of export development of all types of fertilizers (own elaboration based on data from International Trade Centre (2023))

Country	Value of all types of fertilizers exported (USD million)				k_{03-22}	k_{13-22}	k_{21-22}	$\overline{k}_{03-22}$
	2003	2013	2021	2022				
World	18,843	66,198	84,029	135,840	7.21	2.05	1.62	1.11
Russia	1,964	9,121	12,495	20,969	10.67	2.30	1.68	1.13
Canada	1,840	6,605	6,607	13,729	7.46	2.08	2.08	1.11
China	800	6,253	11,472	11,380	14.23	1.82	0.99	1.15
USA	2,549	5,022	4,621	8,472	3.32	1.69	1.83	1.07
Morocco	372	1,925	5,715	7,715	20.76	4.01	1.35	1.17

Table 4. Analysis of export development of nitrogenous fertilizers (own elaboration based on data from International Trade Centre (2023))

Country	Value of nitrogenous fertilizers exported (USD million)				k_{03-22}	k_{13-22}	k_{21-22}	$\overline{k}_{03-22}$
	2003	2013	2021	2022				
World	7,051	27,482	35,512	60,142	8.53	2.19	1.69	1.12
Russia	660	3,358	4,472	7,222	10.94	2.15	1.61	1.13
Oman	0.054	906	1,498	4,976	92,139	5.49	3.32	1.83
China	434	3,284	4,449	4,923	11.34	1.50	1.11	1.14
Qatar	278	2,187	2,410	3,577	12.86	1.64	1.48	1.14
Saudi Arabia	431	1,028	1,722	3,221	7.48	3.13	1.87	1.11

Regarding the leading exporters of all fertilizers, China is the only country whose export of all fertilizers decreased interannually. Beyond this exception, the majority of countries conform to the prevailing general trend expressed by the average growth coefficient of the world's export of fertilizers. Russia demonstrates its predominance in this field by being the leader for the last decades.

Russia also stands as the leader in the export of nitrogenous fertilizers. As this is a long-term trend, the focus was on the countries that experienced notable changes in recent years. Among the primary exporters of nitrogenous fertilizers, Oman exhibits a notably higher growth of the value exported than the other countries. In 2003, Oman occupied the 91st position with a trade balance of −3.374 million USD. However, it has since ascended to the second position with a trade balance of 1,460 million USD.

The comprehensive findings indicate that the overarching trend on a global scale does not exhibit substantial differences between the development of the trade with all types of fertilizers and the trade with nitrogenous fertilizers. The average growth coefficients present similar values, with the exception of Oman.

4. Discussion

Global consumption of nitrogen fertilizers is expected to reach 108 million metric tons in 2024, reflecting a global trend of increasing demand. This increase results from lower fertilizer prices, leading to increased purchasing by farmers. Furthermore, global consumption is expected to increase until 2030, albeit at a more moderate annual growth rate (Quinn, 2023). However, the International Fertilizer Association (2022) claims that the global commodity market will remain disrupted in contrast to pre-2020 levels (International Fertilizer Association, 2022).

Regarding the results being found within the analysis, the first finding was that Brazil stands as the preeminent importer. It imports more than 80% of its total fertilizer needs. This trend is partly due to limited domestic resources and capacity for fertilizer production, forcing the country to rely on imports to meet the needs of its large agricultural sector (United States Department of Agriculture, 2022). In 2022, fertilizer imports to Brazil reached record volumes, driven by concerns about potential fertilizer shortages due to international conflicts and trade sanctions (Samora and Mano, 2022). Geopolitical events such as the Russia-Ukraine conflict have significantly impacted global fertilizer supply chains. Brazil, dependent on imports, especially from Russia, faced the risk of supply disruptions. In response, the Brazilian government took international diplomatic action and concluded agreements with several countries, including Iran and Russia, to ensure the continuity of fertilizer supply (United States Department of Agriculture, 2022).

Another specific feature is the production of nitrogenous fertilizers in the Middle East. According to Mosier et al. (2004), the decision to produce nitrogenous fertilizers is primarily determined by the availability of raw materials, notably natural gas and crude oil. The rapid increase in the export of nitrogenous fertilizers by Middle Eastern countries can be attributed to the abundance of those resources (Mosier et al., 2004).

Among the Middle Eastern countries, Oman experienced the most enormous export growth. It is a result of the fact that it has abundant natural gas reserves, a key raw material for fertilizer production. Natural gas serves as the primary input for the production of ammonia and urea, which are essential components of nitrogen fertilizers. The country is also strategically located on the Arabian Sea, which facilitates the export of fertilizers to major Asian markets such as India, Bangladesh, or Pakistan (Mendoza, 2023). Due to the region's low natural gas cost, fertilizer production costs in Oman are low. This makes the construction of export-oriented, integrated urea plants very attractive (Wainwright, 2018).

In the context of the global fertilizer market, countries such as Saudi Arabia, Iran and Qatar have emerged as major producers of ammonia and urea in the region. While global fertilizer demand and supply are changing, Oman and other Middle Eastern countries seek opportunities in export markets, particularly in Asia (Wainwright, 2018).

Regarding the European Union's trade with fertilizers, the main trading partners for the individual states are also members of the EU. For example, the two largest EU exporters, Belgium and Netherlands, traded in 2022 mainly with each other or with France and Germany (International Trade Centre, 2023). However, trade with countries outside the EU contains numerous uncertainties. One of the contemporary concerns is the preeminence of Russia as the primary importer to the EU. The Ukraine conflict's inception emphasizes the sensitivity of this matter for the following years. According to the European Commission, the European Union's reliance on imports and susceptibility to market volatility increases. Therefore, prudent measures have to be implemented to face current challenges to ensure the availability and affordability of fertilisers and, in a broader context, the whole food security. Besides the direct support for farmers and fertilizer producers, the European Commission emphasizes trade diversification to ensure the availability of fertiliser production sources and mitigate risks associated with possible supply disruption (European Commission, 2024).

5. Conclusions

A comprehensive understanding of the global trends in fertilizer markets necessitates a holistic perspective that integrates economic, environmental, and technological dimensions. This evolving landscape underscores the necessity for stakeholders to adapt their strategies to maintain competitive advantages. Particularly in nitrogenous fertilizers, the increasing participation of Middle Eastern countries, notably Oman, represents a significant shift in the market dynamics. This transition not only reflects changing geopolitical influences but also highlights the critical role of technological advancements and environmental considerations in shaping future trade patterns. As the global demand for agricultural yields intensifies, these factors collectively point towards a more interconnected and dynamic global fertilizer market.

Addressing the first research question, the analysis elucidated Russia's prevailing influence in the area of fertilizer exports and Brazil's predominant role in imports. However, it is necessary to note that the trade dynamics, particularly concerning nitrogenous fertilizers, are experiencing a rising tendency in states within the Middle East. The overall direction has manifested a growing movement towards an increase in trade volume; however, strongly affected by the inscrutability of the key commodity prices.

The dual analysis of the general fertilizer market and nitrogenous fertilizer market presented the growing importance of nitrogenous fertilizers as the share of total fertilizer export is increasing. The market with nitrogenous fertilizers has also shown the differences among the main actors, as the market with nitrogenous fertilizers involves Middle Eastern countries as the main actors.

Conflict of interest: none.

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Bottom-up Efforts for a Low-Carbon Economy: Examples of Local Action Groups Activities in Poland and the Czech Republic

Gabriela TRNKOVÁ[1]*, Marek FURMANKIEWICZ[2], Maria KOLA-BEZKA[3] and Richard J. HEWITT[4]

[1] University of Hradec Kralove, Hradec Králové, Czech Republic; gabriela.trnkova@uhk.cz

[2] Wroclaw University of Environmental and Life Sciences, Wrocław, Poland; marek.furmankiewicz@upwr.edu.pl

[3] Nicolaus Copernicus University in Toruń, Poland; mkola@umk.pl

[4] Spanish National Research Council, Madrid, Spain; richard.hewitt@cchs.csic.es

* Corresponding author: gabriela.trnkova@uhk.cz

Abstract: Actions to counteract and adapt to rapid climate change caused by human activity require large-scale initiatives undertaken by international agencies and central governments as well as changes in the functioning of local economies and communities. In this article, we analyze the possibilities of involving rural territorial partnerships (so-called Local Action Groups; LAGs) in supporting the transformation of the EU local socio-economic systems towards a low-carbon economy (LCE). LAGs operate as associations of local stakeholders from the public, business, social and voluntary sectors and work for local socio-economic development. They can implement projects supporting energy transformation at three levels: as cooperation projects between LAGs and external institutions, as individual (own) projects, and by supporting grassroots initiatives of local stakeholders. In this paper we present examples of such activities, based on content analysis of LAGs strategic documents and websites. We point out that the potential of LAGs in supporting initiatives towards LCE is currently underused, which may be due to the low social awareness and low financial resources of local communities. However, LAGs have significant potential to support local pro-environmental initiatives using neo-endogenous development mechanisms, in which voluntary local actions are stimulated by external support.

Keywords: low-carbon economy; circular economy; local action groups; bottom-up actions; Poland; Czech Republic

JEL Classification: Q01; Q5; P25

1. Introduction

The implementation of an economy with low- or zero- greenhouse gas emissions is an important global goal, postulated primarily by scientists and pro-climate non-governmental organizations (Sengupta et al., 2020). Rapid anthropogenically-driven climate change is expected to have serious negative impacts on the economy and living conditions of people in many countries (OECD, 2015). According to climate scientists, slowing down global warming and supporting a rapid energy transition will be less costly than subsequent adaptation to the effects of catastrophic climate change, such as flooding of coastal cities,

rapid changes in agricultural zones, desertification of new areas, and drinking water deficits (Köberle et al., 2021; Mendelsohn, 2009). Efforts to reduce emissions of various types of greenhouse gases, especially carbon dioxide from the combustion of fossil fuels are therefore needed across all sectors of the global economy. This implies broad transformation of energy policy at the national level (Piwowar et al., 2017), as well as changes in the economies and population habits at the local level in rural and urban areas (Bedsworth & Hanak, 2013; Belčáková et al., 2019; Campbell et al., 2016).

The European Union (EU) attaches great importance to the issue of climate change and the need to transform energy systems to support a low (or zero-) carbon economy (LCE) (Maris & Flouros, 2021). The advancement of the energy transition is highly dependent on public subsidy (Kazak et al., 2020; Kozera et al., 2022). However, funding is mainly directed towards the public sector and entrepreneurs, and to a lesser extent to investments in individual farms or private households (Kata et al., 2022). Both governmental and non-governmental organizations can play an important role in investing in energy efficiency and local renewable energy (RE) sources, as well as educating the population and promoting climate-neutral behavior. Pan-European efforts to promote policies favoring the development of LCE are often referred to as "Europeanization", due to the need to adopt similar legal and economic solutions in all EU member states (Strunz et al., 2015).

Various types of cross-sectoral partnerships in the EU can play an important role in educating local communities, and promoting and supporting investments beneficial for the shift towards LCE (Chatterton & Style, 2001), including Local Action Groups (LAGs) (Furmankiewicz & Janc, 2011; Kola-Bezka, 2023). LAGs operate mostly as associations for the sustainable socio-economic development of territorially compact areas, usually smaller than administrative regions, and group together local stakeholders representing the public, business, social and voluntary sectors. LAGs create local development strategies (action plans) and redistribute a specific pool of financial resources from EU funds for projects prepared by local NGOs, small entrepreneurs, farmers and public entities (Kola-Bezka, 2020; Konečný et al., 2020). LAGs can also support local activities related to ecological education and small investments supporting energy transformation (Ministry of Agriculture and Rural Development, 2012). However, literature on the role of LAGs in the development of LCE (including RE) in rural areas is relatively scarce (Furmankiewicz, Hewitt, et al., 2021; Kola-Bezka, 2023; Olar & Jitea, 2020), hence we decided to explore and develop the discussion on this topic.

In this paper, we present the results of our preliminary research on the LAGs activities in Poland and the Czech Republic, both of which have supported the energy transformation through activities like the promotion and development of distributed renewable sources of electricity and heat, as well as energy saving measures. As part of our research, we posed the following two research questions (RQ):

- (RQ1) Based on the analysis of the literature and published reports (pre-analysis): what main types of projects related to the implementation of LCE can potentially be

implemented by LAGs, due to the source and organization of financing for local activities?

- (RQ2) Based on our own research of LAG websites and documents (main research): what types of activities do LAGs actually undertake in these types of projects, i.e. whether they are investment projects, analytical services, or promotional and educational activities?

Due to the fact that LAGs in Poland and the Czech Republic are relatively small local associations (Zajda, 2014), the starting assumption for our research is that LAGs will not be active in the implementation of large investment projects, but will rather undertake service activities typical for the third sector - educational and analytical.

We discuss the results of our research in the context of the concept of LCE (Dzikuć & Dzikuć, 2020; Kazak et al., 2023; Sengupta et al., 2020), with particular emphasis on the conditions and policies of the EU (European Commission, 2019a; Lucas, 2008). Our analysis may be useful for policymakers preparing programs to support local communities financially, as well as for local communities and LAGs managers looking to implement local projects related to LCE.

2. The Importance of Low-Carbon and Circular Economy

Two broad terms are associated with the energy transition: low-carbon economy (LCE) and circular economy (CE), which are closely related (Xie et al., 2023). LCE (also called decarbonized or zero-carbon economy) implies the generation and use of energy and raw materials in ways designed to avoid or minimize emissions of greenhouse gases. Currently, the greatest attention is paid to reducing the burning of fossil fuels that emit carbon dioxide. CE is a broader concept. It focuses on the principle of circulating material flows within product and material systems with the minimization of resource depletion, waste, and emissions (Munzarová et al., 2023).

Both energy saving (increasing the efficiency of energy use) and changing energy sources and technologies for the production of goods and services to those that do not emit greenhouse gases can help transform energy production and use to support LCE (Kazak et al., 2023; OECD/IEA/NEA/ITF, 2015). These goals can be achieved by, for example, abandoning technologies based on the combustion of fossil fuels containing the element carbon, or by introducing a circular economy in which all resources are to be used more efficiently by sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible.

The LCE concept includes energy production systems based on non-renewable fuels that do not emit greenhouse gases (e.g. nuclear energy). However, the CE concept introduces stricter transformation requirements. Under CE, virtually all non-renewable fuels (including radioactive materials) would be eliminated and the extraction of all types of non-renewable raw materials is to be reduced. CE requires the full use of RE and maximizing the level of recycling of all types of raw materials used by humans, with particular support for the use of biodegradable raw materials. However, while CE is more

difficult to achieve, in the long term it is necessary due to limited resources of many types of raw materials. LCE and CE are relevant to the concept of sustainable development (SD) (Geissdoerfer et al., 2017) and can be seen as promising strategies for achieving it (Schroeder et al., 2018).

LCE and CE concepts are important in the European Union (Kola-Bezka, 2024), of which Poland and the Czech Republic have been members since 2004. The key document setting the goals of the EU's energy transformation is currently "The European Green Deal", released by the European Commission in 2019 (European Commission, 2019a). It provides a roadmap for making the EU's economy modern, resource-efficient and competitive, while preserving Europe's natural environment, tackling climate change and making Europe carbon-neutral by 2050 (Maris & Flouros, 2021). The EU has the ambition to carry out the transition in compliance with the 17 Sustainable Development Goals designated in the United Nations 2030 Agenda, and LAGs can participate in this process (Vávra et al., 2022).

Since 2019 the Commission has worked on specific policy developments to put the Deal into action. One area embraced the new EU action plan for the CE (CEAP II) adopted in March 2020 (European Commission, 2020). Building on previous work undertaken on CE since 2015, the CEAP II focuses on resource intensive sectors where the potential for circularity is high. The aim of the plan is to keep resources in economic cycles as long as possible. The aim should be implemented through just transition policies and processes, to avoid that economic changes do not increase social inequality or civil unrest or reduce business competitivity in the sectors affected (European Commission, 2019b).

Actions supported by the EU funds should be consistent with the EU strategic objectives and documents. In this sense, LAGs are also required to demonstrate compliance of local goals with higher-level documents (national and EU) in one subsection of their strategy (action plan) document (Furmankiewicz, Janc, et al., 2021).

LAGs can play an important role in promoting the energy transition at the local level through a range of different activities and initiatives, e.g. information campaigns, workshops and training sessions on LCE, RE and energy saving (Kis et al., 2012; Kola-Bezka, 2023). They can also work as platforms for exchanging knowledge and experiences among key local stakeholders to increase public awareness of the benefits of RE and the efficient use of energy, including through social media (Foronda-Robles & Galindo-Pérez-de-Azpillaga, 2021). LAGs enable cooperation between various local entities to develop and implement projects that are related to a modern LCE concept (Furmankiewicz, Hewitt, et al., 2021). These LAGs initiatives can support the introduction of LCE practices on local level and the efficiency of sustainable policy of local governments (Babczuk et al. 2017; Vávra et al., 2022).

3. Methodology

The subjects of this research were initiatives developed by LAGs operating in Poland and the Czech Republic related to LCE, and especially to energy transformation. LAGs are relatively small associations with three main kinds of revenues: regular small membership fees within the association, private donations and funds for administrative support of the

office under contracts for the implementation of the CLLD approach in the 7-year budget perspectives of the EU support (Chmieliński, 2011).

We took into consideration mainly projects implemented in the frame of EU 2014-2020 financial perspective ("Programming Period"). In practice, the activities were carried out in the years 2015-2023, as the implementation and settlement time of the EU projects was extended due to the COVID-19 pandemic. In the analyzed period, there were 324 LAGs in Poland and 180 in the Czech Republic (Furmankiewicz & Campbell, 2019; Vávra et al., 2022).

In the first stage of the research (January-June 2023), considered as pre-analysis in qualitative research (Piñeiro & Rosenblatt, 2016), we collected literature, published reports and documents on LAGs and support programs that were used by LAGs to determine the general types of projects they could implement. On this basis, we distinguished the general types of projects described in section 4.1. and we have prepared a list of keywords for further webometric analyses.

In the second, main stage of research (September-November 2023), we used text mining methods (Gaikwad et al. 2014). They consisted of finding keywords using an Internet search engine, using logical functions, in order to find information about projects implemented by the LAGs related to LCE (Table 1). In a similar way, we searched available LAG development strategies in which such activities could be planned. Webometric methods, including searching for information using keywords and qualitative analyzes of the content of the surveyed organization websites, are currently used in scientific research (Bachmann, 2012; Foronda-Robles & Galindo-Pérez-de-Azpillaga, 2021; Furmankiewicz, Janc, et al., 2021; Munzarová et al., 2023).

Table 1. Keywords used in the webometric logical procedure for searching for information about LAG projects related to LCE, using logical functions "AND" and "OR"

Key words in Polish:	"projekt" AND "lokalna grupa działania"	AND	"niskowęglowa" OR "energia odnawialna" OR "energooszczędność" OR "energetyczna" OR "gospodarka cyrkulacyjna" OR "gospodarka o obiegu zamkniętym"
Key words in Czech:	"projekt" AND "místní akční skupina"	AND	„nízkouhlíkové" OR „obnovitelná energie" OR „úspora energie" OR "energie" OR „oběhové hospodářství"
Translation to English:	"project" AND "local action group"	AND	"low carbon" OR "renewable energy" OR "energy saving" OR "energy" OR "circular economy"

After searching for records using the described text mining procedures, we qualitatively analyzed the first 50 records to confirm whether they referred to a specific project implemented with the participation of LAGs and to exclude repetitions. The search procedures were the only way to gather information on projects that have been funded from different sources. The collected records included information on LAG websites, fragments of their strategies published in PDF format and information from other sources. Ultimately, we selected descriptions of 6 projects implemented in the Czech Republic and 10 projects implemented in Poland for detailed qualitative analyzes in this article. We then used qualitative document content analysis (Sandelowski, 2000). We focused on the project objectives and the scope of the works completed (if they are services, education or

investment activities). We paid no attention to financial issues due to limited access to comparable statistical data.

The main limitation of our research is that it is based on text mining and case studies which were selected on the basis of researchers' prior knowledge, rather than complete cases or a statistically random sample. Our research was exploratory in nature, consisting of collecting preliminary information about a phenomenon that is not yet well developed in the literature. In such a case, it is permissible to use a trial based on data availability, rather than randomized one (Babbie, 2011).

4. Results

Section 4.1. contains the results of our pre-analysis, i.e. the identification of three main types of LAGs actions. In the next sections we analyze examples of these actions: cooperation projects (type 1, section 4.2), LAGs' own (individual) projects (type 2, section 4.3) and support for other beneficiaries' projects by LAGs (types 3A and 3B, section 4.4).

4.1. Pre-Analysis: Identification of the Main Types of Projects Which Can Be Conducted by LAGs

From the point of view of possibilities for the LCE implementation, in literature, reports and the documents cited in our paper related to EU funds spending, we identified three main possible types of projects related to LAGs activity:

1. Cooperation projects, i.e. projects carried out by LAGs in cooperation with other LAGs or other entities at national and international level (see e.g. Chmieliński, 2011; Epa-Pikuła et al., 2019; Furmankiewicz & Trnková, 2022; Ministerstwo Rolnictwa i Rozwoju Wsi, 2019; NSMAS, 2015; Pisani & Burighel, 2014; Zajda, 2013),
2. Individual LAG projects financed from funds obtained from supra-local sources, in which the LAG is a main contractor (see e.g. European LEADER Association for Rural Development, 2016; European LEADER Association for Rural Development, 2019; Ministry of Agriculture and Rural Development, 2012),
3. Supporting and/or advising bottom-up projects of local stakeholders. In this case, LAGs are intermediary organizations that either: A) fund local projects by redistributing external grants accessed from EU funds through the Community Led Local Development (CLLD) approach (see e.g. Cejudo-García et al., 2022; Chmieliński, 2011; Ministerstwo Rolnictwa i Rozwoju Wsi, 2019; NSMAS, 2015), or B) support local societies in preparing projects to other external institutions, so supra-local funds (see e.g. European LEADER Association for Rural Development, 2019; Ministry of Agriculture and Rural Development, 2012; Novák 2022). In these both cases, local stakeholders in the LAG's area of operation are the main final contractors.

In the next stage of our research, we searched for examples of projects in the text mining procedures. The case studies are analyzed in the following sub-sections.

Examples of LAGs actions for cooperation projects financed under the CLLD approach are dominated by soft projects involving the exchange of knowledge and information, implemented both with domestic and foreign partners. The cooperation projects were popular especially between LAGs operating in Poland. In international projects, Polish LAGs most often became familiar with new ideas and technologies in countries and regions that are leaders in energy transformation. Most of the cooperation projects were financed from national Rural Development Programme 2014-2020 (sub-measure 19.3) and from EU Interreg support program in border regions.

One example is the international cooperation project entitled "Renewable energy sources – the future of the area of local action groups", implemented by the LAG "Biebrzański Dar Natury", the LAG "Kraina Mlekiem Płynąca" (Poland) and association Energievision Frankenwald e.V. (Germany). The representatives of Polish LAGs took part in a study trip to Germany, to learn about technical solutions for distributed, local RE.

Another example is the ECO-North project, led by a LAG from Finland, partnered by LAGs from Latvia, and Poland and a non-governmental organization from Estonia. As part of the project, educational youth camps were held about ecology and environmentally friendly solutions. The participants practiced, among other things, preparation of a model ecological enterprise. A study trip for representatives of LAGs from post-socialist countries to Finland was also important, in order to become acquainted with modern solutions related to circular economy.

Investment activities were carried out less frequently under national cooperation projects and rather as complementary elements of soft actions. For instance, in the EKO LAG project developed by three LAGs from Poland ("Krajna nad Notecią", "Czarnoziem na Soli" and "Dolina Wełny"), in addition to educational activities, eight so-called "eco-points" were created. At each eco-point air quality sensors were installed to make residents aware of the harmful effects of emissions from the burning of fossil fuels in domestic stoves. Another example is the project developed by two LAGs "Między Prosną a Wartą" and "Długosz Królewski" (both from Poland) entitled "Ecological land of the area of active and creative countrywomen", which included both educational actions and the purchase of hybrid street lamps powered by a photovoltaic panel and a small wind turbine.

LAG "Opavsko" (Czech Republic), Municipality of Lisková (Slovakia) and LAG "Dolný Liptov" (Slovakia) implemented project "Vision of an energy-saving region on the territory of the municipalities of MAS Dolný Liptov". It was financially supported by EU Interreg V-A Slovak Republic–Czech Republic program (Small Projects Fund). The goal of the project was the transfer and application of knowledge in the implementation of energy-saving technologies in the municipal economy. Another example is the cross-border project of the association "Krajské sdružení MAS Jihočeského kraje" (covering 16 LAGs from Jihočeský region in Czech Republic), Energy Center "České Budějovice (Czech Republic) and LEADER-Region Mühlviertler Kernland (Austria) entitled: "Energy for communities - solutions for the future" financed under the EU Interreg V-A Austria–Czech Republic

program. As part of the project, "Ambassadors for community energy" (local advisors) were trained and educational brochures "Community energy for municipalities" on RE development in Czech and German were published (Novák, 2022).

4.3. Individual LAG Projects Financed from Supra-Local Sources

LAGs operate as associations that are legal entities and can individually apply for additional funds from various public and private institutions. Most of the identified projects related to LCE concerned educational, training and consulting activities, typical for NGOs. For instance, LAG "Svatojířský Les" (Czech Republic) participated in the "EnKO" project financed by the Next Generation EU fund. The project involved providing free consultations for local communities about increasing energy efficiency and promoting energy-saving, by trained staff.

Another interesting case is the completed project "Mobile autonomous resilience container" carried out by the "Opavsko" LAG from the Czech Republic. This project included an energetically self-sufficient mobile exhibition presenting to local society technologies that can be used in adapting to and mitigating climate change. This project was supported by European Environment Agency and Norway Grants, financed from Iceland, Liechtenstein and Norway.

LAG "Kłodzka Wstęga Sudetów" (Poland) won external financial resources for the project entitled "Active citizens" from the Active Citizens National Fund program, funded by the Financial Mechanism of the European Economic Area and the Norwegian Financial Mechanism. As part of the project, five "Citizens' Meetings" were organized, including: topics of climate neutrality, energy poverty, energy transformation and circular economy in the LAG area of operation. Similarly, the "ECO LEADER" project implemented by LAG "Owocowy Szlak" (Poland) was an example of promotion and education about ecology among children and youth. The goal of the project was to raise knowledge and awareness of ecology, environmental protection and counteracting climate change.

4.4. Local Projects Selected or Supported by LAGs

LAGs act as intermediaries in the distribution of public funds for bottom-up projects submitted by local stakeholders with headquarters inside LAG territories. The most commonly identified local projects were those financed by the EU funds under the CLLD approach. Each LAG has a Decision-making (project selection) Council (as it is called) composed of representatives of various economic sectors, which evaluates and ranks submitted applications. The best projects receive funding successively according to their rank until funds are exhausted.

Some LAGs specified preferences for RE or energy savings in their regulations for assessing project proposals of local entities—for example, proposals that include the use of renewable energy sources (RES) in the form of micro-installations and activities related to improving the energy efficiency of facilities (e.g. "Nasze Roztocze" LAG from Poland). One successful action case is the project "RES micro-installations in the Brańsk commune - Grant project from LAG", submitted by the local commune (rural municipality) to a grant

competition held by LAG "Brama na Podlasie" (Poland) and chosen for implementation by the LAG's Decision-making Council. In this project, individuals with the right to use a residential building located in the commune could apply for subsidies for the installation of photovoltaic cells for their own needs. Similar grant competition "Investments for ecology and renewable energy in households" was announced by LAG "N.A.R.E.W. " (Poland). Under this grant scheme, local communities applied for money for the construction of new solar thermal energy units (water heating) on residential buildings, including single-family private buildings. A further valuable example is the LAG "Turystyczna Podkowa" (Poland) project supporting local RE installations, co-financed through EU structural funds under the Regional Operational Program of the Małopolska Voivodship for 2014-2020.

Another way in which LAGs can carry out activities related to LCE development is by using their own staff to assist with the preparation and implementation of local inhabitants' projects under national or regional support programs. One such case is the involvement of LAGs in the Czech Republic in the New Green Savings ("Nová zelená úsporám") Light subsidy program of the Czech Ministry of the Environment, focused on energy savings in buildings. The program focuses on reducing the energy consumption of residential buildings (through insulation), construction or purchase of houses with very low energy consumption, environmentally friendly heating methods, RES, and adaptation and mitigation measures in response to ongoing climate change. The LAGs help applicants from vulnerable groups (the elderly, people at risk of energy poverty) to prepare a submission.

LAGs in the Czech Republic also play an important role in supporting the development of energy communities. As of 2023, about 17 community energy associations have been established in the Czech Republic, thanks to the activities of LAGs. This type of activity was much rarer in Poland. For example, the LAG "Zielony Wierzchołek Śląska" was involved in the creation of an Energy Cluster "Green Energy of the Forest Land" within its area of operation. Its main goals are the development of RE to counteract emissions from local solid fuel boilers and stoves.

5. Discussion and Conclusions

In our analysis we found that LAGs can engage in implementation of LCE actions at three levels: as cooperation projects between LAGs and external institutions, as individual (own) projects, and by supporting grassroots initiatives of local stakeholders (answer to RQ1). They were active primarily in popularizing the ideas of LCE among local communities (educational activities and consulting) especially in relation to dispersed, local RE development and energy savings. They were less involved in the implementation of infrastructural investments supporting the implementation of LCE goals (answer to RQ2). We confirmed our starting assumption that LAGs, being associations, conduct mainly educational and service activities typical for the third sector, which was also visible in research in other countries (Cejudo-Garcia et al., 2021).

Our research suggests that LAGs relatively rarely engaged in or supported projects related to the implementation of LCE. In our webometric search procedure, we found only a dozen or so examples of projects described by LAGs, related to LCE issues (between 324

existing LAGs in Poland and 178 in Czech Republic). The relatively weak interest of local communities in investments in RE for the elimination of fossil fuels has already been described in the literature (Navrátil et al., 2021). In many EU countries, local communities operating through LAGs participated to a relatively small extent in counteracting climate change (Furmankiewicz, Hewitt, et al., 2021; Olar & Jitea, 2020). This may be because, in rural areas, LCE and global climate change issues were not at the forefront of local stakeholders' interests. For these stakeholders, local environmental impacts like visible emissions from local fossil fuel combustion, had a higher priority (Šťastná & Vaishar, 2023). This is not only because of the low level of social awareness of the importance of energy transformation, but also because of the scarce financial resources of the rural population in post-socialist countries in Central and Eastern Europe (Soloviy et al., 2019). Barriers to transformation at local level include both the reluctance of residents to change their traditional behavior (Feuer et al., 2020), as well as energy poverty - understood not only as the lack of resources of individual households to meet basic energy needs, but also as the lack of funds to invest in modern technologies related to RE production and energy-saving infrastructure (Piwowar, 2020). It is an unfortunate paradox that despite the extensive opportunities present in many rural areas (i.e. abundance of renewable natural resources), the social, economic and political disadvantages they suffer make it difficult to engage rural communities in energy transition (O'Sullivan et al., 2020). As a result, energy transitions in Europe are mostly led by richer countries, e.g. Norway, Finland, Denmark. Their societies can afford to finance technical innovations in the field of LCE (e.g. investments in thermal modernization of buildings, heat pumps, electric cars) (Eikeland & Inderberg, 2016).

However, as case studies show, LAGs can be an important driver for local energy transition. This finding is supported by other analyzes of LAG initiatives in RE and energy efficiency throughout Europe, including in Eastern Europe (Pechancová et al., 2022; Kola-Bezka, 2023). The project examples we have highlighted here show that LAGs have the potential to promote LCE in rural areas. The key issues therefore are how to increase the interest of local communities in behaviors and investments that support LCE, and how to reduce local socio-cultural and economic barriers to their development. These are valuable topics for further research.

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Importance of the Criterion as a Part of MCDM Analysis: Case Study on the Slovak District Towns

Roman VAVREK

VSB – Technical University of Ostrava, Ostrava, Czech Republic; roman.vavrek@vsb.cz

Abstract: Selection of suitable criteria for subsequent application in multi-criteria analysis requires deep knowledge of the specific issue. Subsequent determination of the importance of selected criteria, which directly determine the results of the entire analysis, is no less important. The objective of this article is to identify the differences between various methods of determination of the importance of criteria. A total of 71 local government subjects (district towns) in the Slovak Republic were selected, which were assessed on the basis of 5 criteria. Total debt, debt service and current account balance can be included among these criteria. The importance of the criteria is gradually assessed using 3 objective methods and the obtained results are compared to each other. We state significant heterogeneity of the results depending on the method used. Approaches in one group of methods result in varying importance of criteria, which subsequently gives different results of multi-criteria analysis. The requisite attention and time need to be devoted to selection of a specific method and the results also need to be interpreted in the context of any limitations.

Keywords: municipality; Slovakia; weight of criterion; objective approach

JEL Classification: B23; E69; H11

1. Introduction

At a time of increasing global competition, which we can also identify the 21st as, we need to devote increasing attention to effective expenditure of funds (Hsieh & Fu, 2014; Pevcin, 2014) or identification of alternative sources of funds (Wu et al., 2013). Decisions made on the basis of multiple criteria are gaining popularity and application of this method can be found in various areas of the public and private sectors. The performance evaluation of local self-government entities is very difficult as their primary goal is not to make a profit, but to provide services to their residents that will contribute to an increased quality of life. In this context, it is necessary to evaluate their activity from the viewpoint of several and available criteria, for which it is possible to find relevant and recognised sources.

In general, it can be stated that the result of application of the multi-criteria method (MCDM) is directly determined by the individual making the decision. Pekár and Furková (2014, p. 147) consider the process of determining the importance of the criteria being analysed very important, because the "weights affect the final order and incorrect determination of weights can result in changes to the order and preference of other alternatives". Also by the way they select an approach or a method for determining the importance of individual criteria. Liu and Yin (2019) offer a method for classifying these methods, whereas they identify two groups of methods. Dutta et al. (2021) work with three groups, whereas Keršuliene et al. (2010)

use four groups of methods for determining weights, which represent expansion of the previous classification methods, during which time the groups in question are:

- subjective,
- expert,
- objective,
- integrated.

Subjective methods reflect the personality of the individual making the decisions and his/her individual preferences (the weight of the indicator is determined on the basis of subjective opinion). Expert assessment is carried out by a smaller number of experts in the given field, during which time application of this method in the past is presented by Kendall (1970) or Fisher and Yates (1963). Use of a group of experts and the method of pairwise comparison of criteria (e.g. using the Fuller triangle method) can be found in research by Cambazoğlu et al. (2019); Diaz and Cilinskis (2019) or Polikarpov et al. (2019). The third group, i.e. the group of objective methods, assigns weights to individual criteria on the basis of a previously determined mathematical model, which is unique for each method. The decision-maker therefore has no direct influence on determination of the importance of criteria, but selects according to preference of the properties of the used data, e.g. depending on variability or relations between criteria. This group includes methods such as the Mean Weight method (Paradowski et al., 2021), Standard Deviation method (Ouerghi et al., 2018), Mahalanobis-Taguchi System Method (Yuan & Luo, 2019), λ bi-capacity model (Zhang et al., 2020), Coefficient of Variance method (Vavrek & Bečica, 2022) and others (e.g. Singla et al., 2018; Yalcin & Unlu, 2018). The last group is the integrated methods, which represent a combination of the methods described above.

The presented research works with three approaches to determining the importance of the analysed criteria from the group of objective methods, specifically the MW (mean weight), CV (coefficient of variance) and SD (standard deviation) methods. These approaches are gradually introduced, together with identification of their use in research by various authors. The results of application on real data from the local government area in the Slovak Republic are presented in the last section.

2. Methodology

The goal of the paper is to identify the differences arising from various methods for determining the importance of criteria. For this purpose, three objective approaches to determining the importance of criteria are selected and applied to data from 2020, in a structure recommended by INEKO (2022), which is also used by Vavrek (2019):

- K1 – Total debt,
- K2 – Debt service,
- K3 – Current account balance,
- K4 – Obligations past their due date,
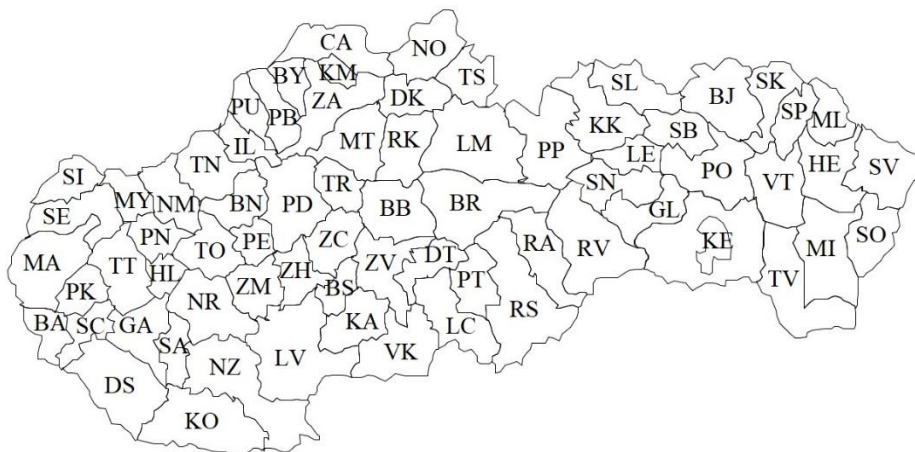- K5 – Obligations at least 60 days past their due date.

Figure 1. Local administrative division of Slovakia (districts)

Within the meaning of Act No. 221/1996 Coll., on the territorial and administrative organisation of the Slovak Republic, as amended, the territory of the Slovak Republic is divided into eight regions and 79 districts (Figure 1). Only 69 of the 79 districts have district towns, with the exception of five districts in the self-governing Bratislava region (Bratislava I district, Bratislava II district, Bratislava III district, Bratislava IV district, Bratislava V district) and five districts located in the Košice self-governing region (Košice I district, Košice II district, Košice III district, Košice IV district, Košice-surrounding area district). In addition to these 69 district areas, INEKO assesses the financial health of the municipal authority of the capital city of Bratislava and the city of Košice, i.e. the total number of assessed subjects within the terms of the presented research is 71.

2.1. Procedure for Using Objective Methods to Determine the Importance of Criteria

The 1st method (MW method) considers the individual criteria to be equally important (equal), during which time the weight of each criterion is calculated using the following formula:

$$w_j = \frac{1}{n} \tag{1}$$

where: n – number of criteria.

The 2nd approach (CV method) is a representative of the objective methods of determining the importance of criteria, working with their variability in relative terms. Its use in research is various, moment characteristics (Sangnawakij & Niwitpong, 2017; Mokrá et al., 2021) and CV graph (Tran et al., 2019) are supplemented by a parameter for determining importance. In this method, the importance of the assessed criteria is determined on the basis of the coefficient of variance (Coefficient of Variance method – CV) using the formula:

$$w_j = \frac{CV_j}{\sum_{j=1}^{n} CV_j} = \frac{\frac{\sigma_j}{\overline{x}_j}}{\sum_{j=1}^{n} \frac{\sigma_j}{\overline{x}_j}} \tag{2}$$

where: CV_j – variation coefficient of j-th criterion; n – number of criteria; $\overline{x}_j$ – average value of j-th criterion.

The 3rd approach (SD method) is also a member of the objective group of method working with variability, but in absolute terms. The importance of the assessed criteria is determined on the basis of a determinant deviation (i.e. the Standard Deviation Method – SD) using the formula:

$$w_j = \frac{SD_j}{\sum_{j=1}^{n} SD_j} \tag{3}$$

where: SDj - standard deviation of j-th criterion; n – number of criteria; $\bar{x}_j$ – average value of j-th criterion.

All analyzes are processed in MS Office Excel, Statistica and Statgraphics.

3. Results and Discussion

The first of the applied approaches is also the simplest, in the case of which all input criteria are equal. In such case, none of the criteria can be identified as more or less important, i.e. there is no option of assessing dominance or determining the order of importance (see Figure 2).
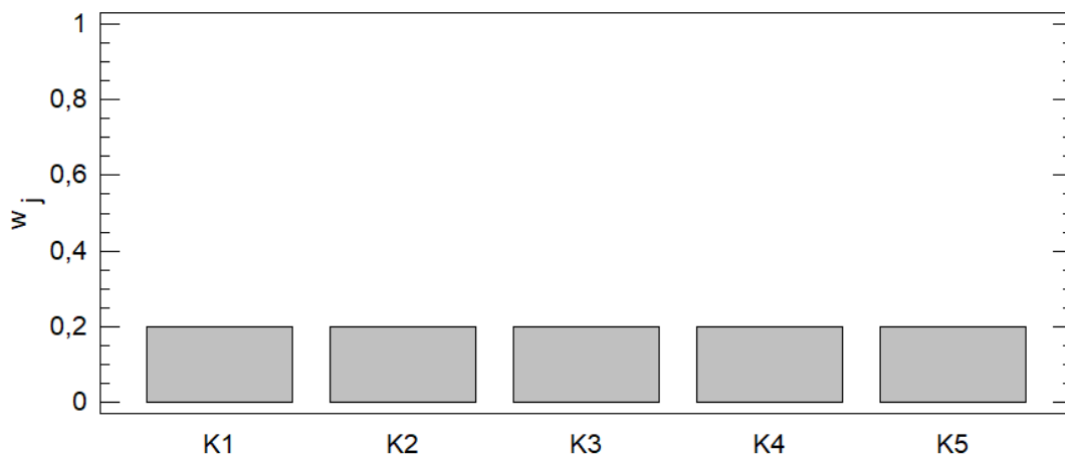

Figure 2. The importance of input criteria from the aspect of the MW method

The principle of the second method of determining the importance of criteria is based on measuring their relative variability by means of a specific moment characteristic, i.e. coefficient of variance. Majority importance is assigned to the last criteria (w_5 = 0.550), during which time the three criteria with the lowest weight are very balanced and oscillate around 5% (Figure 3).
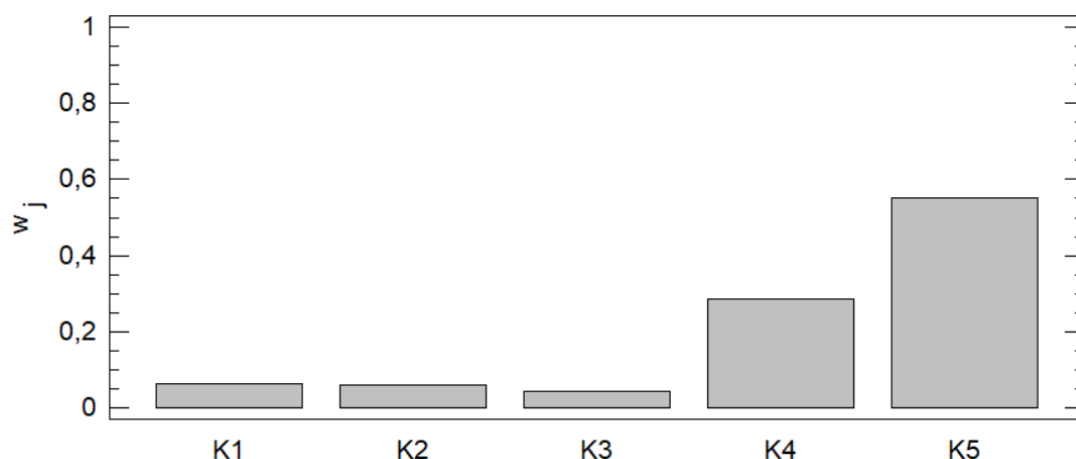

Figure 3. The importance of input criteria from the aspect of the CV method

The principle of the third method used to determine the importance of criteria is based on measuring their absolute variability by means of one of the moment characteristics of variability, specifically the determinant deviation. This method assigns the greatest importance to the first of these criteria, i.e. Total debt ($w_1 = 0.602$). This is followed by two criteria of an importance on the level of 15.21%, or 21.32%. From this viewpoint, the importance of the remaining two criteria is minimal and does not exceed 2% in both cases.
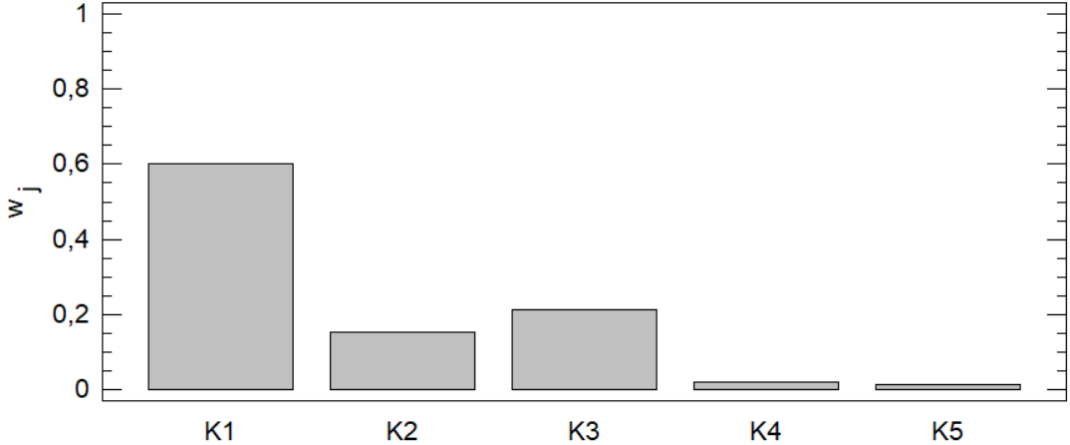

Figure 4. The importance of input criteria from the aspect of the SD method

On the basis of the above, it is possible to identify significant differences arising from application of three simple objective methods for determining the importance of criteria.
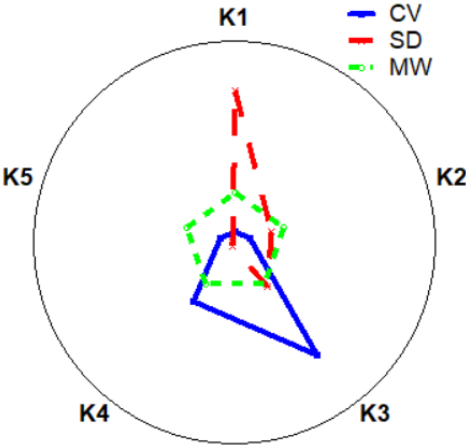

Figure 5. Comparison of the importance of input criteria from the aspect of individual methods

The first of these methods views the individual criteria as equal, which is also reflected in the graph above (Figure 5). During application of the other two methods, we observe significant differences in the obtained results. In both cases, one of the criteria is significantly dominant. On the basis of relative variability, it is possible to identify the most important criterion as K3 - Current account balance ($w_3 = 0.550$). In the case of absolute variability, this criterion is Total debt, i.e. criterion K1 ($w_1 = 0.602$). There was absolutely no consistency in the order of the criteria.
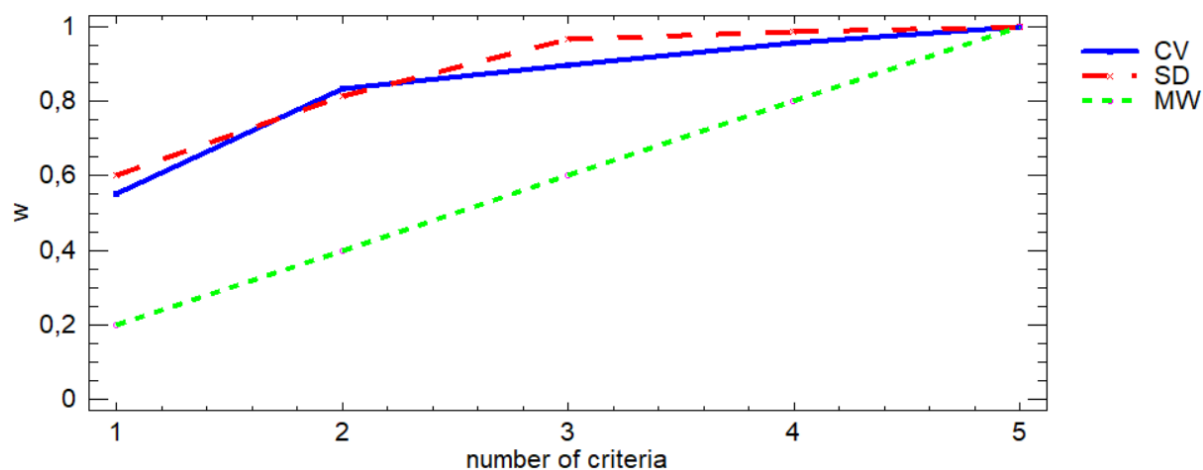
Figure 6. Comparison of the accumulated importance of the input criteria from the aspect of individual methods

The accumulative weight of the criteria is a linear function in the case of the MW method, during which time this grows constantly with the rise of the number of the criteria. In the case of use of the CV method and also the SD method, majority importance is assigned to the two most important criteria (CV: K3 + K4; SD: K1+K3). In both cases, this represents more than 80%. The least important criterion has minimum effect on the results of potential multi-criteria analysis, because the weight assigned to it does not exceed 5% (CV: K1 – 4.36%; SD: K5 – 1.30%).

4. Conclusions

As a result, the multi-criteria evaluation of territorial self-government subjects (in our case, district cities) proved to be highly applicable. In the preceding sections we devoted attention to the importance of input criteria from the aspect of individual methods for determination of such importance, i.e. from the aspect of the MW, CV and SD methods.

Currently, in the conditions of municipalities, single-criteria methods are sporadically used. Many different approaches evaluate a selected group of self-government subject using a different number of criteria, starting with 5 and ending with a group with over 100 criteria. Selection of the method for determining the importance of input criteria has a substantial impact on the results of multi-criteria analysis. The presented research on a simple example confirms this assumption. When selecting a method, even within the terms of one group, a homogenous result cannot be expected. Each of the presented options has its own advantages and disadvantages, which should be taken into consideration when making the final choice.

Conflict of interest: none.

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Obstacles and Solutions to Integrating LCC and LCA

Jan VLACHÝ

University of Chemistry and Technology Prague, Prague, Czech Republic; jan.vlachy@vscht.cz

Abstract: Nowadays, organizations and their decision-makers are expected, and frequently legally obliged, to make commercially sound strategic investments enhancing shareholder value, but also to reckon on their environmental impacts to a degree that substantially exceeds tangible economic incentives to do so. This brings particular challenges whenever the decision process must resort to conclusive and properly documented decision criteria. Accordingly, this paper looks at two fundamental methods, conceptually developed and applied to determine the full economic impacts of decisions, Life Cycle Cost analysis (LCC), and the full environmental impacts of decisions, Life Cycle Assessment (LCA) and at the different possible ways to improve their compatibility and mutual coherence. The key findings of the study indicate that it is meaningful and viable to strive for a partial integration of these methods in a mathematical model in order to analyse the potential for industrial symbiosis in the secondary production and use of alternative construction materials.

Keywords: Life Cycle Assessment; Life Cycle Cost analysis; industrial symbiosis, investment policies; environmental impacts; capital budgeting

JEL Classification: M21; Q51; C52

1. Introduction

Life Cycle Assessment (LCA) and Life Cycle Cost analysis (LCC) have become household terms with businesses, their stakeholders and regulators. However, despite the similarity in their designations and abbreviations, LCA and LCC feature major methodological differences, making them effectively incompatible. These differences arise from the fact that LCA and LCC were originally each designed to provide answers to fundamentally different questions.

LCA aims to assess the relative environmental performance of alternative product systems designed to provide the same function. This is being assessed as holistically as possible, ideally considering all important causally-connected processes, as well as all important resource and consumption flows, regardless of whether or not they eventually impact anyone (Hauschild et al., 2018; Pacañot, 2022).

LCC analysis, in contrast to this, compares the cost-effectiveness of alternative investments or business decisions from the perspective of an economic decision maker such as a manufacturer or a consumer (Flanagan & Jewell, 2005; Dhillon, 2010; Kara, 2019).

These conceptual differences notwithstanding, any decision maker using LCA must also eventually take the economic consequences of into account. However, these are not within the scope of existing LCA methodology, nor are they properly addressed by existing LCA tools. This has limited the influence and relevance of LCA for decision-making, and left largely unresolved the important relationships and trade-offs between the economic and life cycle

environmental performance in decision making (Beaver, 2004; Curkovic & Sroufe, 2006; Helu et al., 2011; Tickner et al., 2019).

A particular domain of policy interest, where this problem arises and its solution may bring substantial benefits, involves industrial symbiosis. By definition, industrial symbiosis represents the physical exchange of materials, energy, water and by-products by industrial entities that are traditionally considered separate. Such exchange can lead to significant reductions in the consumption of primary raw materials and production of waste, while also increasing aggregate profitability and competitiveness through decreased resource costs (Jacobsen, 2006; Neves et al., 2019).

The research presented in this paper starts with a comprehensive insight into the conceptual and methodological differences between LCA and LCC, followed by an annotated summary of available or attempted approaches to their integration. The ultimate aim is to design and develop an extended LCC model, complementary to a LCA model, currently being developed to evaluate the industry-wide symbiotic potential in the construction industry, namely demolition waste, and coal combustion products in the Czech Republic (Paulů et al., 2022). Conclusions will be made on the potential for further research and its results, which will ultimately comprise a mathematical model of an economic system.

2. Theoretical Part

The differences in the purpose of LCA and LCC, respectively, have in due course resulted in major differences in their scope and method, as in Table 1.

Table 1. The main differences between LCA and LCC (adapted from Norris (2000))

Tool / Method	LCA	LCC
Purpose	Building employer brand and prestige, comparing relative environmental performance of alternative product systems for meeting the same end-use function, all from a broad perspective of the society.	Determine cost-effectiveness of alternative investments and business decisions, from the perspective of an economic decision maker such as a manufacturing firm or a consumer.
Activities considered as part of Life Cycle	All processes causally related to the physical life cycle of the product, including its complete supply chain, its use and the supply processes to use, as well as its life termination.	Activities resulting in direct costs or benefits to the decision maker during the economic life of the investment.
Flows being considered	Resources, pollutants and inter-process flows of materials and energy.	Cost and benefit money flows with a direct impacting on the decision maker.
Units for measuring flows	Mainly mass and energy, sometimes also volume or other physical units.	Monetary units (EUR, USD, CZK, ...)
Time scope and treatment	Normally, the timing of processes and their release, and that of consumption flows is ignored. In some cases, impact assessment looks at a time window of impacts (such as a 100-year time horizon for assessing global warming potential), but proper discounting is not used.	Timing is essential in assessment. Present valuing (discounting) of costs and benefits' present value (i.e., discounting) is considered. Analysis is made over a time horizon and any costs or benefits beyond that scope are typically being ignored.

The major issues involved can be demonstrated using a rudimentary example of a desktop PC purchase.

To start with, the life cycles considered by the two methods are different. The time horizon in a LCC analysis comprises the economic life of the investment, at the end of which it is hypothetically expected to be sold at its salvage value. Such a time horizon can actually be shorter than even the use phase in LCA, which in such a case might consider equipment repairs, upgrades or second-hand use.

Also, the process scope of the LCC analysis involves only the processes imposing direct economic costs or benefits upon the decision maker. It thus accounts for the prices of inputs to the investment's economic life, such as the desktop's purchase price, some replacement batteries and the electricity cost, subtracting the salvage value from the life cycle costs. In common with an LCA, costs which are expected to be equal between alternatives (such as software, customer support and peripherals) are normally ignored for the comparison.

For the LCA, on the other hand, all the processes which are causally affected by the life cycles of the alternatives need to be included (only neglecting those which are expected to be identical in the comparison, as in the LCC analysis, as already noted). Accordingly, this would then include the manufacturing of the computer and its components, fuel and electricity delivery to the manufacturers' whole supply chain, electricity consumption of the PC user, as well as the computer's end of life impacts (e. g. those of its recycling or landfilling). An actual LCA may thus easily involve hundreds of process inputs (Silva et al., 2019).

Incidentally, even in its obvious complexity, the LCA scope does not include all environment-related decision-making aspects. For instance, LCA methodology does not strictly require considering the restrictions of environmental laws and regulations, but in the real world these aspects are very important and do need to be dealt with. Subjectivity, assumptions and value judgments also get involved, in the determination of system boundaries, choice of data sources, selection of environmental damage types, of calculation methods, etc. (Pacañot, 2022).

3. Methodology

As shown in the previous section, the two methods feature substantial differences in their flow scopes. The LCC analysis includes only the cost flows; however, these cost flows need not be proportional to, or even be dependent on the physical flows considered in LCA. On the other hand, LCC analysis strictly considers the timing of the cost flows, while LCA neglects this aspect. The LCC analysis, in contrast to LCA, may involve risks involved in the cost assessment, and perhaps the means of their mitigation. This can be summarized as follows (Norris, 2000).

Aspects of the LCA life cycle which are absent from LCC analysis:

- Physical flows having no direct cost impacts on the decision maker;
- Inflows and outflows of any processes outside the LCC-specific life cycle.

Aspects of the LCC analysis which are absent from LCA:

- Cash flows related to product or process change-related investments;

- Cost and revenue flows not proportional to, or even completely independent of the physical flows modelled in LCA;
- The timing of cash flows and their discounting (present valuation);
- Cost- and benefit-related risks and their mitigation.

Properly integrating meaningful economic analysis into LCA thus necessitates an approach far more sophisticated than just treating economic cost as just another physical flow or as another property of physical flows, using e. g. standard LCA software (Su et al., 2020). It needs to add a time dimension, the ability to introduce and account for variables featuring no causal dependence upon inventory flows, as well as the ability to create and involve probabilistic scenarios involving risks. It also must be recognized that LCA methodology is not perfectly standardized, and may thus provide different outcomes in different applications (Silva et al., 2019).

Accordingly, of the two generally possible approaches, extending LCA with economic considerations or extending LCC analysis with environmental considerations, the first option seems less attractive and will only be briefly summarized in the following paragraphs.

3.1. LCECA

In the past, there have been some attempts to start from the traditional LCA framework, adding cost flows and treating them just like physical flows. Nevertheless, such a mindset (that could be called LCA + Partial LCC) did not really augment LCA with capabilities useful in an LCC analysis sense, since it treated costs in ways which were in conflict with the fundamentals of LCC analysis (Norris, 2000). Accordingly, decision making using this approach did not really take into account proper economic criteria.

A relatively well-considered attempt involved Life Cycle Environmental Cost Analysis (LCECA), introduced by Senthil et al. (2003) and aimed at interpreting the outcomes of an LCA in terms of environmental costs. Their model involved a life cycle environmental cost model to estimate and correlate the effects of these costs in all the life cycle stages of the analyzed product. This resulted in newly developed categories of eco-costs which included costs of effluent treatment/control/disposal, environmental management systems, eco-taxes, rehabilitation, energy and savings of recycling and reuse strategies. The LCECA mathematical model then determined quantitative functions relating the total cost of products and the various eco-costs. Finally, the eco-costs of available investment alternatives investment were compared to the computational LCECA model, allowing some conclusions. In a sense, LCECA converges towards the LCC-based eco-cost approach (see also 4.4).

3.2. EIO-LCA

In contrast to the other methods reviewed in this study, this one is not based on calculation, but rather on macroeconomic equilibrium theory. The method's concept stems from the Economic Input-Output Analysis (EIO) by Leontief (1970). Accordingly, it applies equilibrium assumptions to demonstrate the interdependence between production departments within a closed economic system, and then derives a theoretical performance in

its input-output relationships. The linear equation showing the distribution of the industrial production in the whole economic system is then used to find the commensurate yield dependencies (Lave et al., 1995).

EIO-LCA has been applied as an input-output assessment tool of LCA and was developed from the economic values of 519 different commodities published by the U.S. Department of Commerce, aggregating this into the information about economic transactions, resource requirements and the environmental impacts of particular products or services. EIO-LCA thus helps assess relevant contexts of products or services, such as mineral extraction, manufacturing, transportation, etc. (Lave & Kleissl, 2010). Combining EIO with LCA does make some sense, because while they may seem similar in formulation style and calculation methods, they also feature major differences: The EIO approach focuses on the energy metabolism from the socio-economic activities related to input-output, while the LCA approach focuses on the energy metabolism, toxicity, human health and other aspects of the whole life cycle. EIO-LCA thus combines the properties of both methods in an attempt to analyze energy metabolism in all parts of the production chain. Even though the method is quite advanced, with readily available software (Hendrickson et al., 1998), it is still principally LCA-based, however, lacking essential LCC features.

4. Results

We now summarize several possible and previously used approaches to completing LCC with environmental aspects (4.1 - 4.5). The final paragraph (4.6) looks at optimization.

4.1. TCAce

Historically, the attempts to integrate LCC with environmental considerations have been called Total Cost Assessment (Curkovic & Sroufe, 2007) and initially developed in the early 1990's by the Tellus Institute for the U.S. Environmental Protection Agency and the New Jersey Department of Environmental Protection. TCAceIntegrate was the result of a collaborative project by ten multinational companies and the American Institute of Chemical Engineers' Center for Waste Reduction Technologies (Beaver, 2004). The complete analytical process can be summarized as in Figure 1.
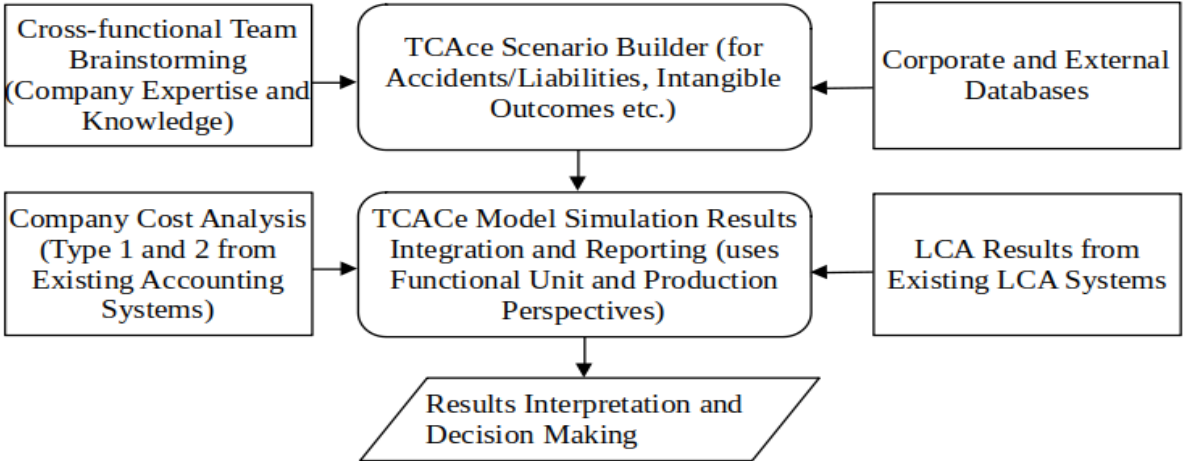

Figure 1. The TCAce process (adapted from Norris (2000) and Beaver (2004))

This schematic representation indicates the method's strong reliance on scenario and Monte Carlo simulation methods.

The TCAce method applies five cost types as summarized in Table 2. Types 1 through 4 comprise internal costs borne by the company; these costs would be included in a comprehensive LCC evaluation of investment alternatives, although traditional LCC analyses typically capture only Type 1 (direct) and some Type 2 (indirect) costs.

Table 2. Cost type breakdown (adapted from Norris (2000))

Cost Type	Description
#1: Direct	Direct costs of capital investment, labour, energy, raw material and waste disposal. May include both recurring and non-recurring costs. Includes both capital and O&M costs.
#2: Indirect	Indirect costs not allocated to the product or process (i.e., overhead). May include both recurring and non-recurring costs. Includes both capital and O&M costs.
#3: Contingent	Contingent costs such as fines and penalties, costs of forced clean-up, personal injury liabilities, and property damage liabilities.
#4: Intangible	Costs that are difficult to measure, including consumer acceptance, customer loyalty, worker morale, union relations, worker wellness, corporate image, community relations.
#5: External	Costs borne by parties other than the company (for instance, society).

The specific design of TCAce enables users to extend the relevant cost scope to include cost types 4 and 5 that are not tangible, applying quantitative methods, consistent with the firms' existing approaches to LCC analyses of Type 1 and 2 costs.

The consistency with existing corporate accounting conventions may include approaches to capital depreciation, treatment of taxes, discounting, and the time horizon of LCC evaluations. Users can also import the results of conventional LCC analyses of Type 1 and 2 costs into TCAce from their existing financial accounting software or databases. In principle, TCAce also provides users with the option of estimating Type 5 costs, which are borne by parties other than the decision-making company, its suppliers or customers. These Type 5 costs may bear a direct relevance to the Life Cycle Inventory data imported by the user into TCAce from their LCA software. Nevertheless, if they are included in the analysis, Type 5 costs must still be recorded separately from internal costs, as they do not directly impact the cost-effectiveness of a decision.

4.2. Weighting Financial LCC with Environmental LCC

The paper by Reich (2005) examined the possibilities and limitations of connecting economic information to a life cycle assessment (LCA) in the process of analysing municipal waste management systems. The author proposed a terminology and methodology for the economic assessment of municipal waste management systems, and tested it in a case study. A distinction was made between a financial life cycle costing (effectively LCC, used in parallel with an LCA) and an environmental LCC that was used as a subsequent weighting tool.

In the case study, the LCC analysis comprised all the costs incurred by the extended waste management system, applied as if the LCA system was a single economic actor. In the environmental LCC, three different weighting methods were used to monetize environmental effects such as emissions and resource use. Notably, both LCC analyses used

the same unit of account, and they were therefore perfectly additive, suitable for use as a welfare-economic tool. This step-by-step aggregation resulted in a transparent and reproducible analytical method.

However, in the particular case, despite the methodology seemingly facilitating the analysis, it was established that major problems remained, due to the fact that municipal waste management diverged from standard economic systems in significant aspects.

4.3. Integrating Contingent Valuation

Bovea and Vidal (2004) proposed a model, which took an interesting approach to calibrating the value of environmental improvements, based on demand. It used an innovative combination of three methodologies: the Life Cycle Assessment (LCA) methodology to determine the environmental requirements, Life Cycle Cost analysis (LCC) to examine the internal and external costs of the product, and Contingent Valuation (CV) to quantify the customer's value in terms of their willingness-to-pay (WTP) for a product that incorporates certain environmental improvements. This shows that the product value can be increased with the use of a design that simultaneously reduces the environmental impact and external costs, while allowing a manufacturer to pursue a profit-maximization strategy.

4.4. Eco-cost

Use of the LCC analytical framework, while adding some elements of LCA, such as physical flows from the manufacturer and perhaps first-tier suppliers generally lacks important LCA attributes, and therefore fails to identify decisions that minimize total environmental burdens over the full life cycle (Norris, 2000). One possible course of addressing this involves eco-cost, as in Dejaco et al. (2020), who applied it to residential building technologies. An interesting conclusion was that while the carbon tax (as used in Austria) had a 5% impact on total life-cycle costs of a building, and thus had little impact on decision-making, using the full eco-cost (quantified via the IPCC estimate of 135 €/tCO_2 equivalent) increased the impact to 20%, becoming highly relevant.

4.5. Circular Economy Application

Recent research has advanced the integration concept into the objectives of transitioning from the linear economy to a Circular Economy (CE). Namely, Alejandrino et al. (2022) suggested the integration of an existing environmental life cycle assessment of organizations (O-LCA) and a proposed life cycle costing of organizations (O-LCC) to identify and select possible CE improvements for industrial firms. The concept is shown in Figure 2.

After an initial diagnosis, ten CE improvements were selected and applied in eight alternative scenarios. The application showed that although all the alternative scenarios were beneficial from the CE perspective, considering the environmental and economic effects gave routinely different outcomes.
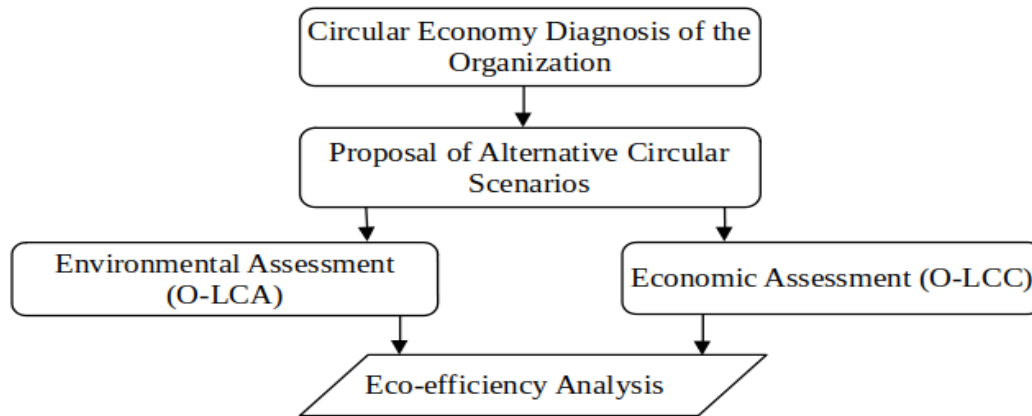
Figure 2. Integrating O-LCA and O-LCC to assess Circular Economy (Alejandrino et al. (2022))

4.6. The Optimization Problem

The relationship among economic and environmental aspects in integrated evaluation is often not in balance. This means that optimization is as important to consider as integration. Because of the nature of the decision-making process in the LCC and LCA context, the optimization problem will inevitably become multi-objective. Many studies have been carried out on multi-objective optimization and numerous potentially relevant optimization models can be found in literature. We start with the ones considering more general, but potentially related factors, such as quality and reliability, followed by those specifically considering environmental factors.

In the first category, Wright et al. (2002) developed a multi-objective optimization model to optimize HVAC (heating and cooling installation) system design and control parameters with two design objectives: to minimize the operating cost for the design days and, at the same time, to minimize thermal discomfort. Frangopol et al. (2001) focused on LCC analysis combined with civil construction reliability, which was further developed by Okasha and Frangopol (2009) using genetic algorithms to optimize in the domain of structural construction system problems considering system reliability, redundancy and the life cycle cost. Brown and Salcedo (2003) proposed the application of multiple-objective genetic optimization to a naval ship design problem, where the critical objective attributes taken into account were mission effectiveness and cost.

More closely related to LCA, due to their involvement of physical units (mass, energy), were the study of Fragiadakis et al. (2006), where the material weight and life cycle cost were the two objectives optimized by an Evolution Strategies Algorithm, and that of Hamelin and Zmeaureanu (2012), who performed an optimization of a family house envelope, using two objective functions, the life cycle primary energy use and life cycle cost.

Early adopters of multi-objective optimization involving LCA were Azapagic and Clift (1999), who used a three-objective system optimization in LCA as a means of identifying and evaluating the best possible options for environmental management of the product system. Their method offered the decision-maker a choice between two alternatives, Best Practicable Environmental Option (BPEO) and Best Available Technique Not Entailing Excessive Cost (BATNEEC), the second of which considered costs, albeit in a subordinate role.

Verbeeck and Hens (2007) performed a life cycle optimization for extremely low energy dwellings aiming at reducing financial costs and environmental impact over the life cycle. The environmental impact was evaluated through a life cycle inventory of the whole building, whereas costs were evaluated through a cost-benefit analysis. The multi-objective optimization problem was addressed by combining genetic algorithms and the Pareto concept. The results included a discussion of the trade-off curves of primary energy consumption and net present value, an analysis of the embodied energy, and a study of the impact of economic parameters, such as price developments exceeding inflation and discount rate.

More recently, Ostermeyer et al. (2013) proposed a multidimensional Pareto optimization methodology using LCC and LCA in the context of building refurbishment.

5. Discussion and Conclusions

It is clearly seen that numerous researchers have encountered the need to integrate the results of LCA and LCC analysis. Therein, two distinct possible objectives may be observed: One, primarily focused on perceived societal needs, which gave rise to approaches essentially based on LCA, i.e., the environmental aspects, such as LCECA and EIO-LCA, but also to some of the multi-objective optimization proposals. These methods' outputs may well be attractive for policy makers, as tools for the identification and, perhaps, promotion of broad policy objectives, but can hardly be considered as useful decision-making tools on the micro level in a market economy, fundamentally driven by economic incentives (in contrast to a directive-driven economy). It then remains to be seen what is available in terms of extending LCC analysis to include LCA considerations.

In the current project, focusing on industrial symbiosis, the design develops in three consecutive stages. First, separate LCA and LCC models have been created in a way that tightly coordinates the structure of inputs (these include a comprehensive dataset on relevant producers, products and their relevant parameters, including geographical locations), and with common partial objectives (such as identifying environmentally and economically break-even transport distances for material substitution).

LCC and LCA results will now be compared using several case studies of technologically viable and tested industrial symbiosis (one current case involves fly ash produced by coal combustion that can have several secondary uses in construction, besides landfilling), in order to establish whether, under circumstances, they can bring broadly compatible results. This stage will include sensitivity analyses to external developments in inputs, but also to potential policy actions, such as new or increased charges at different nodes of the system, subsidies to intermediate processing etc.

This will, in the ultimate stage, facilitate the creation of a single comprehensive model of industrial symbiosis, using LCC as well as LCA inputs, whose LCC component will be using real or transfer pricing in each of its nodes. Its intended use will be to guide the actions of company decision-makers, as well as to simulate the anticipated response of industry to policy actions. Research-wise, the model will also contribute to a better, empirically tested understanding of the integration potential of LCA and LCC analyses.

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Circular Economy from the Perspective of Accounting Data During the Pandemic Period

Miroslava VLČKOVÁ

University of South Bohemia in České Budějovice, České Budějovice, Czech Republic; mvlckova02@ef.jcu.cz

Abstract: Circular economics refers to a system where production systems are designed to be self-contained regarding resources, allowing for their reuse. The focus of this paper is to analyze accounting data, such as the assets, liabilities, costs revenues, and cash flow for the companies that have implemented elements of the circular economy. The analyzed accounting data were from the period before the pandemic and the period of the pandemic. Statistically significant differences were found in the indicators of long-term financial assets, capital funds, other operating revenues, residual cost of long-term assets and materials, and interest income. The analysis also indicates that companies, unable to fully engage in their business activities, invested more in long-term (financial) assets, which generated profit in the form of interest income, and had to resort to selling part of their long-term (tangible) assets and inventory. The identified statistically significant differences indicate that the pandemic period had a significant impact on the financial and operational activities of companies, which had to adapt to new conditions and strategically invest in long-term assets. These changes in indicators suggest the necessity of adapting and optimizing business strategies in response to emerging challenges.

Keywords: analysis of the financial indicators; circular economy; COVID-19; Mann-Whitney U test

JEL Classification: A13; M41; O44

1. Introduction

The primary objectives of the circular economy involve reducing resource consumption, which is limited, and instead emphasizing the reintroduction of previously utilized raw materials or waste back into the production process. The circular economy can be defined as an economic model characterized by minimal consumption of primary materials, simultaneous reuse of resources, and high-quality recycling of basic materials. It has gained significant popularity as an approach in today's world. The EU Circular Economy Action Plan 2020 outlines a forthcoming strategy for the European Union (European Union, 2020). "The Secondary Raw Materials Policy of the Czech Republic" is the first document in the Czech Republic that establishes a strategic framework for the efficient utilization of secondary raw materials. The increasing interest in the secondary raw materials industry can be attributed to the continually rising prices of primary resources, their availability within the EU, and, most importantly, the significant material and energy savings that result from their utilization (MPO, 2015).

The circular economy also promotes the shift towards renewable energy sources, fostering economic, environmental, and social capital. It is built upon principles such as waste and pollution minimization, the perpetual cycle of products and materials, and the regeneration of natural systems to ensure value for future generations. Circular economy often adheres to the 3-R approach for resource utilization, which comprises (Kirchherr et al., 2017): 1. Reduce (minimizing the use of raw materials), 2. Reuse (maximizing the reuse of products and components) and 3. Recycle (achieving high-quality reuse of raw materials). The circular economy has a growing trend. This is indicated by the rapid growth of peer-reviewed articles on this topic. More than 100 articles were published on the topic in 2016, compared to only about 30 articles in 2014 (Geissdoerfer et al., 2017). The implementation of circular economy elements may appear straightforward and akin to the simple reuse of resources in today's context. However, there are numerous obstacles in the field of circular economy that hinder companies from enhancing their involvement. These obstacles encompass administrative procedures, regulations, etc. Companies that choose not to participate in the circular economy system often perceive significant barriers in terms of administrative requirements, financing, investments, and costs (Garcés-Ayerbe et al., 2019).

The concept of accounting refers to the systematic process of recording, analyzing, interpreting, and reporting financial transactions and information of an organization. Accounting involves the measurement, classification, and communication of financial data to provide stakeholders with relevant and reliable information for decision-making, financial planning, and performance evaluation. The concept of accounting in relation to the circular economy has already been addressed by several authors. For example, Fischer-Kowalski et al. (2011) deal with the most modern ways of accounting for material flows in the whole economy and at the same time examine the reliability and uncertainty of data in the accounting for material flows. Cleveland et al. (2000), on the other hand, examine energy flow accounting, so-called energy accounting, and discuss suitable indicators for the analysis of ecological systems and the amount of energy put into the production. They found that companies with high environmental performance tend to be profitable. King and Lenox (2008) found evidence of a link between lower environmental pollution and higher financial value. Södersten et al. (2020) introduce a novel measure of material utilization called CAMF - capital-augmented material footprint, which encompasses all materials incorporated within capital assets. Their findings emphasize the importance of comprehensive indicators in evaluating the potential for mitigating the impacts of material and product consumption. As resources become increasingly scarce and the desire for well-being grows among consumers and various societal segments, there is a pressing need for new economic models that can enhance resource efficiency and effectiveness (Ghisellini et al., 2018).

The COVID-19 pandemic has had a significant impact on the global economy for over two years. It has led to an economic downturn and the onset of a crisis. The pandemic caused disruptions in global supply chains, resulting in a slowdown in production, industry, and trade worldwide. Unemployment rates increased, and small and medium-sized enterprises (SMEs) were particularly hard-hit.

In 2020, the Czech Republic experienced the largest decline in gross domestic product (GDP) in its history, with a contraction of 5.6%. However, the year-on-year decline was moderated to 4.7% due to foreign demand. Furthermore, the state debt increased to 36.5% of GDP in 2020, compared to 28.5% in 2019. The state budget deficit in 2020 reached CZK 367.4 billion, significantly surpassing the planned CZK 40 billion deficit. The deficit was observed throughout the year, with the highest levels occurring during the spring and autumn months, likely due to stringent government restrictions. State budget revenues decreased by 3.1% due to tax reliefs (ČSÚ, 2021).

The aim of this paper is to analyze the financial data of companies obtained from balance sheets and profit and loss statements in the pre-pandemic and pandemic periods. Two hypotheses are set to fulfill the objective: H1: Balance sheet indicators (some items of assets and liabilities) show a different trend during the pandemic period. H2: Values from income statements (some items of costs, revenues, and profit and loss) or cash flow exhibit a different trend during the pandemic period.

2. Methodology

The data for the analysis were gathered from two sources. In the initial phase, it was necessary to determine whether the companies under study had implemented elements of the circular economy or not. This information was collected through questionnaire surveys, creating a proportional sample of over 12,900 enterprises to match the distribution in the Czech Republic. In 2020, data were obtained from 245 companies, representing an almost 2% response rate. The companies were then classified based on their engagement with the circular economy. Out of the total 245 analyzed enterprises, it was found that 102 had implemented elements of circular economics, while 143 had not.

In the subsequent steps (in the years 2021 and 2022), the accounting data values were determined for these classified companies using the Albertina Gold Edition database. However, financial data could only be obtained from 160 out of the 245 companies. The companies were further categorized based on the implementation of circular economy elements for research purposes, resulting in 84 companies without implemented elements and 76 companies with implemented elements. The relationship between these factors was then analyzed using a statistical Mann-Whitney U test. This test is used to evaluate unpaired experiments when comparing two different samples. It was tested the hypothesis that two variables have the same probability distribution. At the same time, these variables may not correspond to Gaussian normal distribution, it is sufficient to assume that they are continuous. The test involves the calculation of a statistic, usually called U, whose distribution under the null hypothesis is known. U is then given by (Devore, 2015):

$$U_1 = R_1 - \frac{n_1(n_1 + 1)}{2} \tag{1}$$

where n_1 is the sample size for sample 1, and R_1 is the sum of the ranks in sample 1. An equally valid formula for U is:

$$U_2 = R_2 - \frac{n_2(n_2 + 1)}{2} \tag{2}$$

The smaller value of U1 and U2 is the one used when consulting significance tables. The sum of the two values is given by:

$$U_1 + U_2 = R_1 - \frac{n_1(n_1 + 1)}{2} + R_2 - \frac{n_2(n_2 + 1)}{2} \tag{3}$$

Knowing that $R_1 + R_2 = \frac{N(N+1)}{2}$ and $N = n_1 + n_2$, and doing some algebra, we find that the sum is $U_1 + U_2 = n_1 n_2$.

It was tested the hypothesis H0: $\vartheta1 - \vartheta2 = 0$ against the alternative one.

3. Results

As mentioned above, the data for the analysis were obtained from two sources - the first source was a questionnaire (the questionnaire found out which companies have, and which do not have implemented elements of circular economy) and the database as a second source to obtain accounting data from these companies. Based on the Mann-Whitney U Test, the accounting data of companies with the implementation of elements of the circular economy were statistically analyzed for the years 2019 and 2020. These years were selected as sample years, with 2019 including accounting data from the pre-pandemic period and 2020 including accounting data from the pandemic period. The level of significance was determined to p = 0.05.

3.1. Analysis of Differences in Selected Accounting Items of Assets and Liabilities in 2019 and 2020

Within the research, statistically significant differences in the data between the two periods were examined. The analysis focused on the following aspects of the accounting data: a) assets and liabilities, and b) costs, revenues, profit and loss, and cash flow. In the first part of the analysis, a total of 42 active and passive items from the balance sheet were examined. The following table (Table 1) presents the 14 most significant items selected from this group. This analysis is key to understanding changes in the structure of assets and liabilities, which helps to identify key factors influencing the company's results in given periods. The results of the analysis indicate potential strategic points on which the company could focus its attention in order to optimize its financial results in the future.

From Table 1, it can be concluded that the only statistically significant difference at a significance level of p-value 0.05 is observed for the indicator of long-term financial assets. Looking at the graphical representation, it is evident that the values of this indicator are higher during the pandemic period, i.e., in 2020. This could be attributed to the fact that companies were unable to conduct their operations as usual during this period and, therefore, they invested their available funds in the form of long-term deposits. If we were to adjust the significance level to a value of p-value 0.10, the indicator of capital funds would also become statistically significant. Once again, the graphical representation shows that the accounting value of capital funds is higher in 2020. Thus, H1 has been confirmed. It is seen the differences in Figure 1. Higher values of the indicator of long-term financial assets during the pandemic

Table 1. Differences in selected accounting items of assets and liabilities in 2019 and 2020

| Financial indicator	Year 2019	Year 2020	U	Z	p-value
Total assets	5,862	5,766	2,840	0.1750	0.8611
Long-term tangible assets	5,264	5,032	2,476	0.3210	0.7482
Long-term financial assets	689	742	224	1.9625	0.0306
Current assets	5,754	5,874	2,828	-0.2193	0.8265
Stocks	4,855	4,875	2,370	-0.1875	0.8513
Trade receivables	5,792	5,836	2,866	-0.0792	0.9369
Current financial assets	5,647	5,981	2,721	-0.6135	0.5395
Equities/Liabilities	5,862	5,766	2,840	0.1750	0.8611
Owner´s equity	5,678	5,950	2,752	-0.4993	0.6176
Capital funds	1,851	2,154	770	-1.7939	0.0728
Total liabilities	5,884	5,744	2,818	0.2561	0.7979
Debts	5,822	5,806	2,880	0.0276	0.9780
Trade debts/liabilities	5,658	5,970	2,732	-0.5730	0.5666
Bank and other loans	5,878	5,750	2,824	0.2340	0.8150
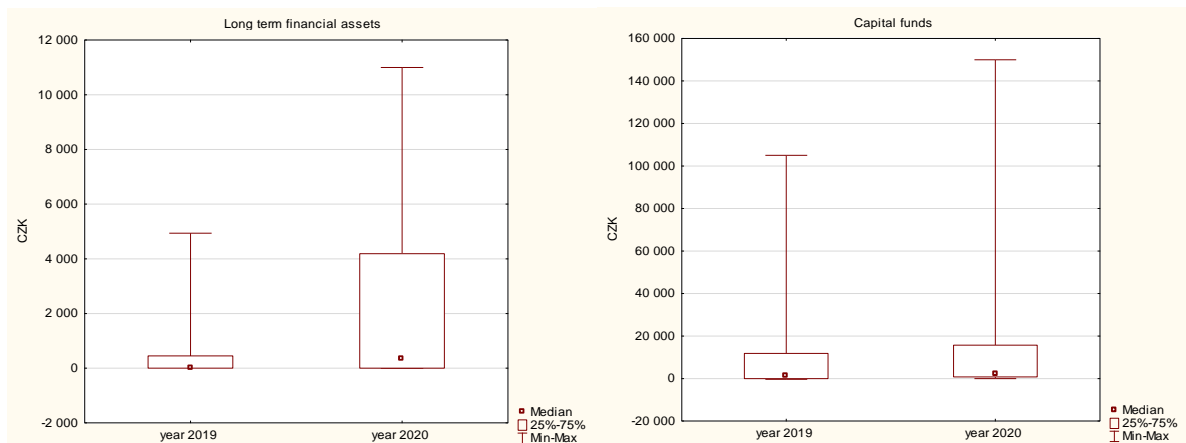
Figure 1. Differences in items long term financial assets (on the left) and capital funds (on the right) in 2019 and 2020

period in 2020 can be interpreted as a reaction of companies to the impossibility of running their normal operations. With limited business opportunities and an uncertain environment, companies probably preferred to invest in long-term deposits as a stable and safe way to appreciate available funds. This move could serve as a temporary measure to maintain asset value and minimize risks in an uncertain economic environment, which explains the observed significant difference in this accounting ratio.

3.2. Analysis of Differences in Selected Accounting Items of Costs, Revenues and Cash Flow in 2019 and 2020

In the second part, 46 items from the profit and loss statement were examined, specifically cost and revenue items, as well as the profit and loss and cash flow value. The following table presents the 14 most significant items selected from this group.

Table 2. Differences in selected accounting items of costs, revenues and cash flow in 2019 and 2020

Financial indicator	Year 2019	Year 2020	U	Z	p-value
Material and energy consumption	3,581	3,440	1,610	0.6971	0.4857
Total consumption	4,862	4,454	2,108	0.8857	0.3758
Other revenues from operating activities	6,366	5,262	2,336	2.0322	0.0421
Revenues from the goods and services sold	5,798	5,830	2,872	-0.0571	0.9545
Labor costs	5,638	5,990	2,712	-0.6467	0.5178
Revenues from the fixed assets and materials sold	5,928	5,700	2,774	0.4182	0.6758
Residual cost of fixed assets and materials sold	6,312	5,316	2,390	1.8333	0.0668
Operating costs	5,756	5,872	2,830	-0.2119	0.8322
Interest income	2,569	2,582	973	1.9576	0.0503
Interest expense	2,744	2,612	1,286	0.2605	0.7944
EBT	5,776	5,852	2,850	-0.1382	0.8901
Total financial costs	5,744	5,884	2,818	-0.2561	0.7979
Total financial revenues	5,418	6,210	2,492	-1.4574	0.1450
Cash flow	5,650	5,978	2,724	-0.6025	0.5468

From the table above, it can be seen that at a significance level of p-value 0.05, there is a statistically significant difference only for the indicator of other revenues from operating activities. When graphically representing this indicator, it is found that its values are lower and in some cases the companies were also incurring significant losses during the pandemic period as you can see it in Figure 2. This could be because companies were unable to sell their products, goods or services and generate revenue.

If we adjust the significance level to a p-value 0.10, the indicators of residual cost of fixed assets and materials sold, as well as the indicator of interest income, would also become statistically significant. Looking at the graphical representation, it can be observed that the accounting value of residual cost was lower in 2020. This may indicate that some companies were forced to sell certain long-term assets or inventory. As for the interest income indicator, it is evident that the interest rates were higher in 2020. This could be attributed to the fact that companies invested in long-term financial assets instead of their own business activities, and these long-term assets generated interest income for them.

The aforementioned analysis shows that during the pandemic period, companies may have faced challenges in generating income from other operating activities, which is reflected in the statistically significant difference in the indicator of other income. H2 has been confirmed.
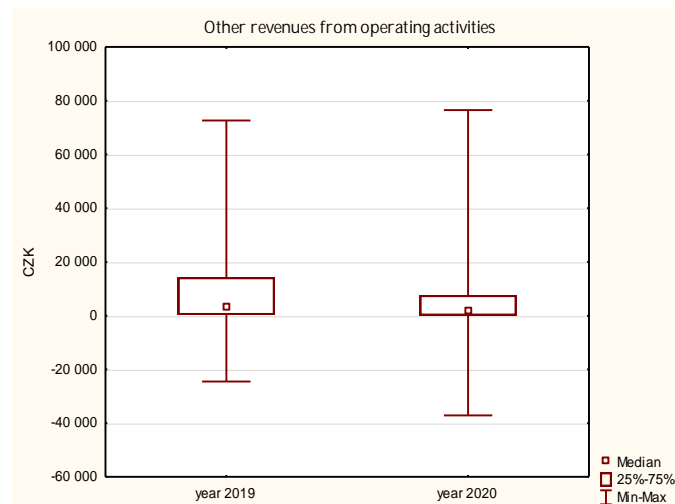
Figure 2. Differences in item other revenues from operating activities in 2019 and 2020

4. Discussion

Circular economy signifies minimizing waste and optimizing resource utilization through reuse, recycling, and material recovery. Vlčková (2020) analyzed indicators in relation to individual elements of the circular economy, which are backup of plastic packaging, increasing the life of packaging; recycling and reuse of waste; and use of renewable resources. In the analysis of financial indicators and the recycling and reuse of waste element, a significant difference was found in the liability's indicator. When analyzing the use of renewable resources element, a difference was found in the fixed assets indicator. In the analysis of the element of backup of plastic packaging, increasing the life of packaging, a significant difference was found in the owner's equity indicator, total assets, operating revenues, and operating costs indicators. All these indicators were lower for companies that have implemented the elements of the circular economy.

This paper focuses on the analysis of accounting data for companies that are affected by the circular economy in the period before the pandemic and during the pandemic. The observed statistically significant differences imply that the period of the pandemic had a notable influence on the financial and operational functioning of businesses, requiring them to adjust to new circumstances and make strategic investments in long-term assets. These fluctuations in indicators indicate the importance of adapting and refining business strategies to effectively respond to the arising challenges.

From the analysis, it can be concluded that during the pandemic period, companies may have faced difficulties in generating income from other operating activities, which was reflected in a significant statistical difference in the indicator of other income. Similarly, Kuo et al. (2010) found a positive correlation with statistical significance in terms of the company's environmental costs, net income, and economic benefits of environmental protection. Regarding the circular economy as such, Franklin-Johnson et al. (2016) focus on the development of novel indicators to assess the environmental impacts associated with the circular economy. They specifically examine a new performance metric called the lifetime indicator, which quantifies the contribution to material retention by measuring the duration

of resource reuse. These performance indicators serve as valuable tools at the management level, enabling the measurement of decision impacts on the longevity of renewable materials.

Scarpellini et al. (2021) highlight the significance of financial resources as a critical factor for investments in the circular economy. They emphasize that from an economic standpoint, barriers to investment are often linked to low levels of profitability and challenges in accessing financing, particularly in certain countries. These factors can hinder the adoption and implementation of circular economy practices and initiatives. As this analysis implements, in the pandemic period these phenomena are further deepened, and risks increase.

The circular economy is not only about accounting data. As with any theory, the circular economy is not without its critics. One of the main criticisms is that the circular economy often overlooks the social dimension, including issues related to gender and racial equality, fair financial evaluation, intergenerational equality, and equal employment opportunities. Critics also highlight the challenges associated with recycling certain materials, such as wind turbines and solar panels, due to their complex composition. Additionally, from a thermodynamic perspective, recycling is criticized because materials tend to degrade in quality and quantity with each subsequent cycle (Rizos et al., 2017).

For future research, it is recommended to analyze the impact of the economic circulation on enterprises in connection with accounting data, with an emphasis on categorizing companies into manufacturing companies, service providers and business companies. This categorization could provide a deeper insight into specific challenges and benefits of the economy in various sectors. Furthermore, it would be useful to examine how different types of companies deal with the principles of the economy circulation and how these changes are reflected in accounting data. Analysis could include the evaluation of the efficiency of the economic circulation in each type of enterprises and identifying areas where sustainability and efficiency can be improved. In addition, the role of accounting indicators could be examined in measuring the performance of companies within the principles of the economy circulation. Taking various branches and types of enterprises, the results could become more specific and applying for specific areas of business.

5. Conclusions

Access to renewable resources, waste minimization and efficient use of resources can play a key role in optimizing costs and increasing sustainability. The implementation of circular practices could lead to innovative approaches to financing and investments that would not only reduce the environmental impact of companies, but also bring economic benefits.

Overall, it can be concluded from the analysis that the impact of the pandemic period on companies was manifested by significant differences in accounting data. The first part of the analysis focused on active and passive items of the balance sheet showed that the only statistically significant difference at the significance level of 0.05 was observed for the indicator of long-term financial assets. This difference can be interpreted as the response of companies to the limitation of normal operations during the pandemic period, when investments shifted to long-term deposits as a stable and safe way of evaluating available funds.

The second part of the analysis focused on the profit and loss statement confirmed a statistically significant difference at the same level of significance only for the indicator of other income from operating activities. A graphical representation of this indicator showed that the values were lower, which may be a consequence of the difficulties of firms in generating income from other operational activities during the pandemic. Adjusting the level of significance to 0.10 revealed statistically significant differences also for Residual cost of fixed assets and materials sold and interest income indicators. Lower residual cost values in 2020 may signal the need to sell long-term assets or inventory. Overall, therefore, the analysis suggests that businesses faced challenges in generating revenue during the pandemic period and responded by changing their finance and investment strategies.

Given the growing interest in sustainability and environmental responsibility, further research could examine how firms integrate circular principles into their financial strategies and how these changes affect their performance and results in turbulent times.

Conflict of interest: none.

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Measurement of Innovation in the Core Industry of China's Digital Economy: A Text-based Approach

Jie WEI[1], Yuhang SONG[2*] and Yujia REN[1]

[1] Nanjing University, Nanjing, China; winniewei@nju.edu.cn; renyujia95zz@163.com

[2] Northwest University, Xi'an, China; 2350625274@qq.com

* Corresponding author: 2350625274@qq.com

Abstract: With the fourth wave of industrial revolution, the ability to innovate in digital field has become the bottom support of competitive game between countries. This paper focuses on the innovation of the core industry of Chinese digital economy, utilizes the analyst reports of the top 100 enterprises in electronic information industry listed in A-shares, examines the basic characteristics and trends in development of overall innovation and types of China's digital economy by the method of text information mining. Results show that overall innovation of the core industries is currently experiencing rapid progress, many subfields original innovations burst out. Besides, industries incremental innovations and integration of self-developed disruptive technologies has achieved a sense of "curve overtaking". The method of measuring innovation based on text information is a new breakthrough in methodology, which overcomes the limitations of traditional methods, makes up for the technical omissions in measuring unpublished patents or R&D companies.

Keywords: core industry of digital economy; innovation; text information mining; LDA topic model; machine learning

JEL Classification: B41; C55; D21

1. Introduction

The new generation of information technology with artificial intelligence, big data and blockchain as the core is rising strongly, and the digital economy has become an important driving force for global economic development. In recent years, China has seized the opportunity of digital economy development and made new breakthroughs, but the questioning of the current level of innovation in China's digital economy is still a hot issue. Generally speaking, innovation is a multi-dimensional process, and many of its internal processes are difficult to measure. Thus, the research at home and abroad continues on the way to expand the methodology of "innovation measurement" (Haar, 2018). The innovation of electronic information industry as the core industry of digital economy is a typical representative of China's digital economy innovation. At present, China's electronic information industry is taking the initiative to transform the industry to adapt to the development situation at home and abroad, which has shown rapid innovation and high investment growth.

So far, the existing literature mainly focuses on the number of patent applications in electronic information industry (Jia et al., 2021) and research and development input (Liu et

al., 2019; Hao et al., 2020) conducted research, while ignoring the innovation of non-patented and non-R&D enterprises, which may make information omission. In order to further understand the innovation level of electronic information industry, this paper introduces Latent Dirichlet Allocation (LDA) topic model (Blei et al., 2003) to generate the text topic of analyst report, and uses its good characteristics to model massive heterogeneous text data (Wu et al., 2022). Fully associate the text word aggregation class, effectively measure the topic probability of new documents, and improve the overall accuracy and credibility of the measurement (Omar et al., 2015). Based on this, the difflib function in Python is used to compare the differences between texts, select the best topics and constitute the overall measurement of innovation in electronic information industry with words contained in them. Then further discusses the subdivision type, Original innovation and Incremental innovation, which respectively represent the source of breakthrough and creativity by relying on their own internal forces and the deep mining and development of existing technology (Souto, 2015). Thus excavate the current innovation and development situation of China's digital economy and provide reference for the construction of "digital China" in the future.

Compared with the existing literature, the marginal contributions of this paper are as follows: Firstly, provide a textual description of the innovation level of enterprises. This paper uses Python crawler to conduct data mining on the information contained in industry research reports of the top 100 enterprises to measures the innovation level in the electronic information industry, so as to better explore the innovation connotation under the surface of text words, which can overcome the limitations of traditional innovation measurement methods and further expand the measurement scope. The way to measure innovation makes methodological significance. Secondly, Enlightenment for measuring two different types of innovation. On the basis of measuring China's core industries' overall innovation, this paper further subdivides the forms of innovation, and offer a relatively objective quantitative evaluation index for quantifying.

2. Data and Method

2.1. The Informational Nature of the Analyst Research Report Text

Industry analyst reports are highly informative. Most foreign scholars make use of analyst reports to obtain industry information, evaluate the volatility caused by the analyst reports, and make investment decisions (Wei et al., 2023; Tu, 2022; Roeder et al., 2022). Others use analyst reports to look for factors that influence analyst recommendations (Bouteska & Mili, 2023), measure analyst sentiment (Daudert, 2021) and its possible impact on analyst reports. For example, the forecast deviation of corporate earnings (Jiang et al., 2022), the degree of ethical behavior bias (Brown, 2021), etc. In the context of the reform of information disclosure system, analyst research reports issued by securities institutions have become an important tool for mining and interpreting the company's operation situation and predicting the company's future development direction (Allen et al., 2014). In addition, since the content

of analyst reports includes company innovation, it is possible to obtain the true level of innovation output of enterprises by mining the text of analyst reports.

In recent years, the use of enterprise patents to measure innovation has been widely discussed by scholars. Enterprises usually apply for patents to obtain economic benefits and seek property rights protection, but under some circumstances will not, such as the potential loss of efficiency in applying for patents (Bessen & Maskin, 2009), the cumbersome process of filing patents (Shapiro & Lemley, 2019), which mainly lead by the insufficient protection of creators. In addition, there are still some systematic deviations in patent statistics (Pavitt, 1985), and it is limited to measure the innovation level of enterprises only by measuring the number of patent applications and R&D investment. Therefor the content of analyst research reports can reflect other innovative activities apart from patents and research. For example, Coca-Cola does not apply for patents (Halligan, 2010) to prevent the disclosure of trade secrets, but the value of this secret is well known to analysts. And there are many ways for companies to innovate without filing patents or investing in research and development, like Wal-Mart. The top 500 American enterprise has not applied for patents in the early 1990s, but maintained a high growth rate during this period, and has been developing and improving its supply chain system by using information and communication technology to strengthen its service and brand strengths (Bahramimianrood & Bathaei, 2021).

As the core industry of the digital economy, China's electronic information industry is undergoing multiple transformations of industry, products and technology in recent years. Analysts are focusing on the research and development of new products and technologies in the industry, and the information comments and disclosure of related products will help us analyze the innovation field of this area. In addition, analysts are widely regarded as influential participants in the capital markets (Fogarty & Rogers, 2005) and can influence investors who face significant uncertainties about future market developments through their reports (De Franco et al., 2015; Huang et al., 2014). In the operation of the capital market, analysts tend to predict the future development trend of the industry by describing the company's financial performance, which has a certain authority (Stolowy et al., 2022), and thus are considered as important participants in the capital market (Leins, 2018). Moreover, to a certain extent, analyst reports have the internal information privacy of the industry (Naqvi et al., 2021), and they often have a unique sense of smell in the discovery of new products and technologies in order to gain investors' attention. Therefore, this paper uses the analyst research report to analyze the innovation of the core industry of China's digital economy, deeply digs the connotation of the report text, and obtains the technology field that the core industry of the digital economy is currently booming, as well as the specific types of innovation contained in the industry.

2.2. Sample Selection, Data Source and Data Preprocessing

This paper focuses on the core industry of digital technology in China for the year 2022. Top 100 competitive companies in the electronic information industry which shown at the "World Digital Economy Conference 2022" as research object, and focuses on the companies

with A-share listed stocks as research samples. Based on this, the Wind financial terminal database is used to manually sort out the research reports made by analysts of two securities companies, which are Huatai Securities and Everbright Securities, from 2004 to 2023. Then use Python to scrape the report content to obtain the overall samples, which then are de-duplicated, word segmentation and data cleaning.

In order to reduce the noise that may exist in the above process and ensure the accuracy of the obtained content, this paper pretreats the samples in the following ways: (1) Eliminate the enterprises that have not issued A-shares and are not currently listed among the 100 companies in the above-mentioned industries. (2) Research reports published on WeChat public accounts, research reports without permission, research reports with missing data content and restricted research reports only for whitelist users are excluded, and only all available analyst reports published by Wind Financial Terminal are taken as research samples. (3) Clean the content of the research report, delete the report samples with missing content and the invalid pages that repeatedly appear in the report. (4) Use the stop word list to delete common stop words and other words that may interfere with the results. Finally, 1,114 analyst reports from 76 companies were obtained as research samples.

2.3. Construction of Technical Innovation Vocabulary of Core Industries in China's Digital Economy

In order to obtain the current technological development level of the electronic information industry, and find out the initial measurement standard of industrial business, according to the "Electronic Information Industry Classification Notes (2005-2006)" and "Electronic Information Product Classification Notes" (hereinafter referred to as Notes), to build the technical innovation vocabulary of China's digital technology core industry. China's electronic information industry includes 12 industries, aggregate 46 categories, in which the software industry accounts for 1 industry and 3 categories, and the manufacturing industry accounts for 11 industries and 43 categories. This paper uses the product division standard indicated in the notes to define the overall business scope of the electronic information industry, and constructs the initial basic vocabulary to measure the technological innovation level of the electronic information industry.

Firstly, compare and screen the products to find out the complete range of electronic information industry products; Then, the screened words are simplified and associated to obtain phrases that can be recognized by machines, and deleted redundant items, thus to form a basic vocabulary base for measuring enterprise technological innovation. Finally, based on the vocabulary and the definition of electronic information products, compares the word categories of about 1,500 products in the vocabulary within 12 industries, then explore above two types of innovation (part 3.2.).

3. Measurement of Innovation in Core Industries of China's Digital Economy Based on Text Information

This chapter will use Python software to carry out information mining on the analyst report text, refine and measure the current innovation trend of the electronic information

industry (Figure 1). Firstly, this paper uses the LDA topic model to describe the analyst text, utilizes the pyLDAvis, word cloud and other visual tools to show the measurement results. Secondly, use text similarity measure overall innovation of industry. Then, by constructing a basic vocabulary base to measure technological innovation, using Python to search key texts and other means to collect the industrial technological innovation words contained in the analyst report, the level of original innovation and incremental innovation of the industry is obtained. Based on the data mining results, combined with the actual situation of China's electronic information industry, the current innovation development trend of China's digital economy core industry is obtained, then subdivide the specific innovation types.
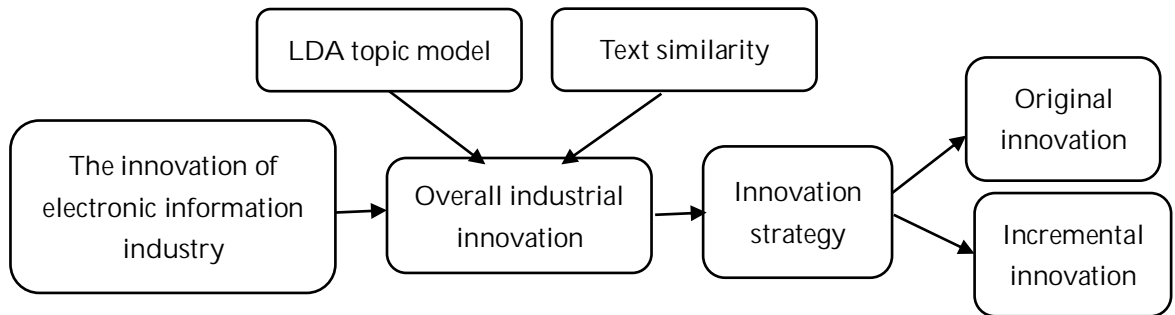

Figure 1. Research frame and process

3.1. Use LDA Topic Model to Measure the Overall Level of Enterprise Innovation

This section mainly uses the LDA topic model to analyze the analyst reports of the top 100 competitive enterprises in China's electronic information industry. Firstly, the optimal number of topics is obtained by constructing the LDA topic model on the crawled reports, and the pyLDAvis visual analysis is carried out. Then, difflib differentiation is compared between the words in the selected topics and the original text, and the topics with the greatest similarity to the innovative textbooks are selected as the optimal topics to measure the overall innovation level, then the display word cloud map is drawn accordingly. Thus, the overall description of the innovation level of the top 100 electronic information industries is obtained.

1. Select the best topic using the LDA topic model

According to the mechanism analysis of the LDA topic model by Blei et al. (2003), it can be seen that LDA model can carry out cross document analysis of given content according to context semantics, effectively extract the document topic, and deduce the probability distribution of the given document topic from the word frequency distribution of the topic, mining and modeling text data (Cao et al., 2009). According to the above definition, in the process of LDA topic analysis, the number of topics is not recovered through data reverse engineering on the basis of fixing itself in advance, but generated by the data itself (Richert & Coelho, 2013), which ensures the reliability of the estimated results. In this paper, Python crawler is first used to crawl text data, and then LDA method is used to construct a dictionary for corpus data and visualize it. By calculating the perplexity curve of LDA model (The et al., 2006), the "elbow method" is used to constantly adjust the value of the
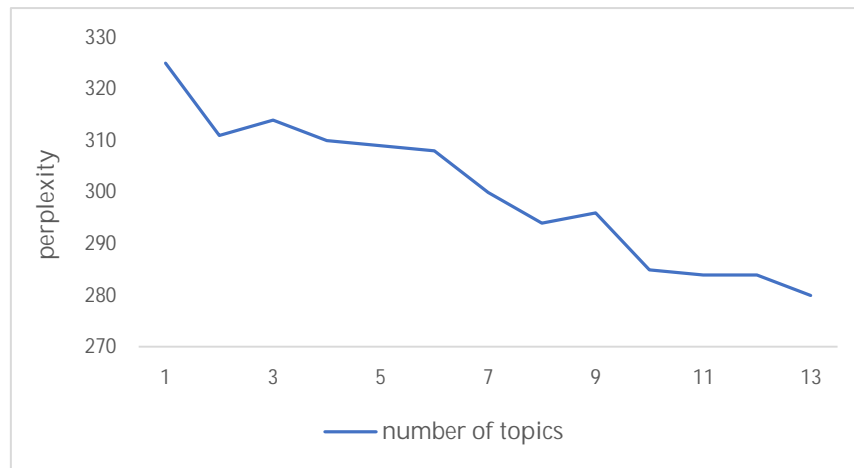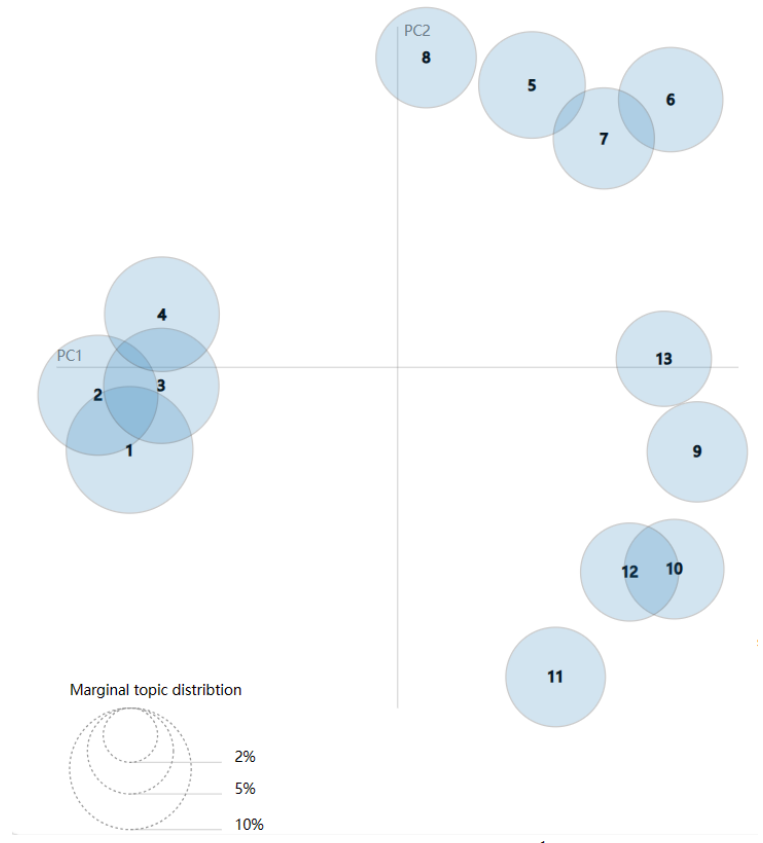
Figure 2. LDA perplexity curve

number of topics k, so that the output topics are kept at a low level of perplexity. Based on this, the optimal number of topics for the target text is determined.
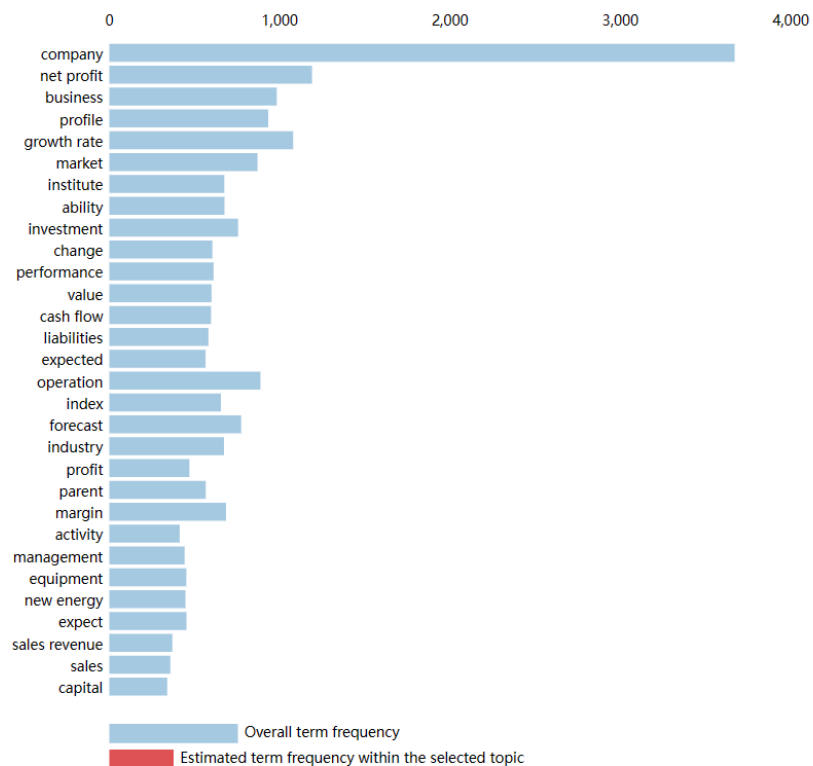
After the above measurement, it is found that the perplexity degree of LDA theme model obtained from the perplexity degree curve is low when the number of topics k=13 (Figure 2). Further, use pyLDAvis to draw theme interaction display graph and verify the suitability of the optimal number of topics obtained from the above perplexity degree curve, then summarize the content of each theme. pyLDAvis is a method that extracts the principal components of text and analyzes them in multiple dimensions. The proximity between subjects is indicated by the distance between subjects. The bubble distance adopts Jensen-Shannon divergence (JSD) distance, and the overlap degree of bubbles indicates the cross-relationship of feature words in the topic (Gottfried et al., 2021). The following Figure 3 shows pyLDAvis images of the above 13 themes. Observing the degree of overlap among the LDA output themes, we can see that the correlation degree among the themes is small and meets the selection criteria of the best theme. Therefore, k=13 is selected as the optimal number of themes output by the LDA theme model.

For each topic obtained by the LDA topic model, the histogram on the right lists the top 30 most relevant words under that topic. Among the 13 topics, we can get the relevant keywords of each topic, and then describe relevant content: In Topic 1, Topic 7 to Topic 13, the LDA model results highlight the future business and operation of the top 100 companies. Here, we output the most relevant 30 words to representative topic 1 to describe the text content (Figure 4, Left). Relevant words express the development of the top 100 companies in the main business: The current revenue and expenses of industries are good, and the gross profit margin has improved overall; Related products are in a rapid development trend, and it is expected that there will be greater breakthrough results in the future; However, in the face of complex domestic and international environment, the industry still has some competition and pressure. The above topics generally indicate that the electronic information industry has significant dividends and returns, in which opportunities and risks coexist. The words in Topic 2 to Topic 6 highlight the general situation of the products of the electronic information industry. The text content related to the representative Topic 2 is output here (Figure 4, Right).

Figure 3. LDA theme topics

Top-30 Most Relevant Terms for Topic 1 (10.9% of tokens)

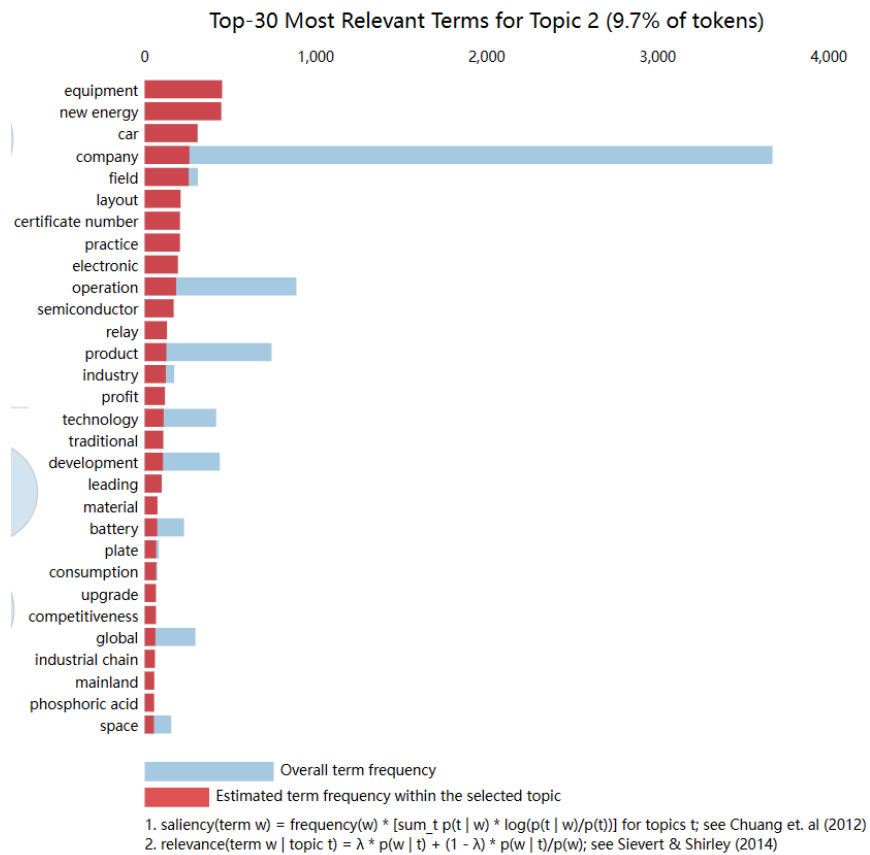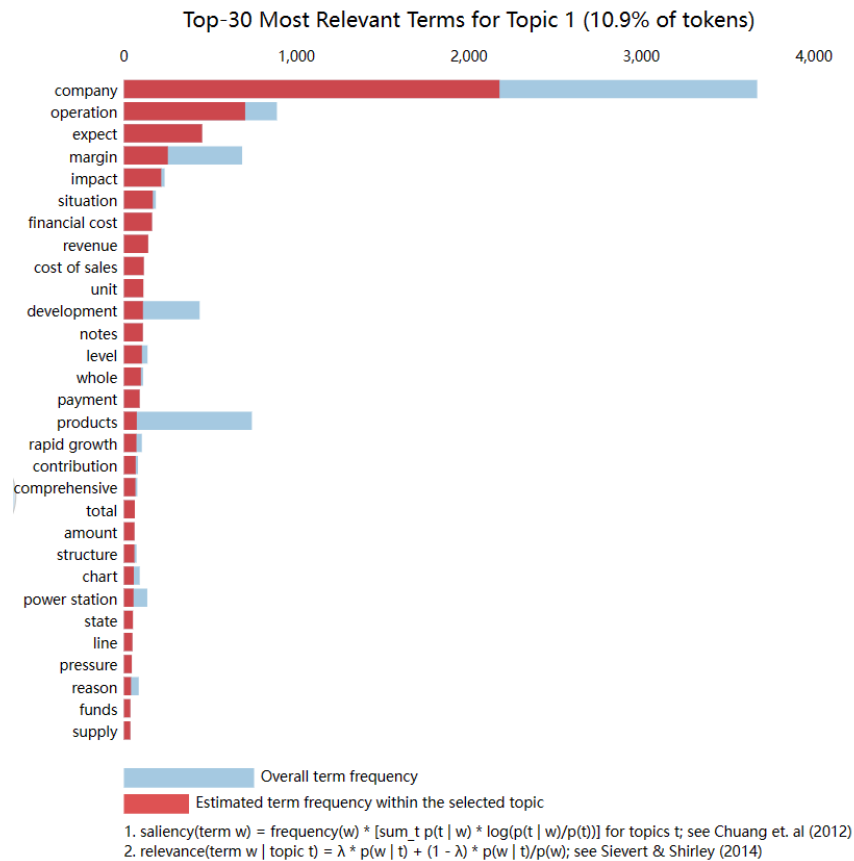## Top-30 Most Relevant Terms for Topic 2 (9.7% of tokens)

Figure 4. The top-30 LDA representative subject words

These topics describe the related products and equipment in the industry, which mainly mentioned new energy, automotive, semiconductor, relay, flexible industry, smart home, base station, robot, optical fiber, chip, Internet and other hot areas of electronic information industry, which not only reflects the current focus of the development of the electronic information industry, but also indicates the corresponding innovation potential and unlimited innovation possibilities in these subdivided industries.

2. Innovation based on text similarity measurement

In order to measure the overall innovation, we select "Corporate Finance" (Zhu, 2018) as the benchmark innovation textbook to measure the text similarity between subject words. The Python crawler is used to extract the text content in the above standard innovative textbooks, the jieba word segmentation is performed to measure the text word frequency of the textbooks, and the word frequency of the words contained in the book (after weeding out invalid words by using the stop word list) is greater than or equal to 100, and the obtained string represents the original text content and is recorded as A; Then, the top 25 words with the highest word frequency among the 13 topics measured above are taken as representatives of the content of each topic, and the string representing the text content of the topic is obtained and recorded as $B_n, (n = 0,1,...,13)$. The difflib module in Python is used to measure the pair similarity of the above strings, and the topic with the highest similarity to the base text is obtained as a proxy for the overall innovation of this paper.

Combined with the output results of the LDA model, the topic with the highest similarity in difflib is directly related to the factors that describe the overall level of innovation in the company from the text content. Figure 5 shows the word frequency. This topic describes words related to finance of the top 100 enterprises. At present, the industry is constantly changing, and the overall development of the industry is great; The increase in capital, interest rate and sales will bring more profits and investment interest, which will increase the market value of the company. Thus, the current market share of the enterprise has relatively high position in this industry, which means that the company which has large market share will have competitive advantages in the overall industry. In addition, it also indicates that enterprises with high value, high growth and high revenue have more characteristics of innovative enterprises. In China's electronic information industry, the overall strength of the company is still the key factor for enterprises to carry out overall innovation.

Apart from that, as a representative product of the overall innovation of the electronic information industry, smart phones have become the focus of analysts. Domestic mobile phones represented by Huawei, OPPO, vivo, etc. have emerged, and the update iteration of Apple has become a hot topic for analysts to discuss. At the same time, mobile phones as a key product of the electronic information industry, which development has also led to a series of related technology innovation, such as chip research and development, flexible folding screen, as well as China has conquered 5G technology and perfect AI technology, big data and other technology innovation, are reflected in the development process of smart phones.

Figure 5. Theme word cloud

3.2. Measurement of Innovation Types in the Core Industries of China's Digital Economy: Original Innovation or Incremental Innovation

This paper further subdivides and measures the overall innovation types of the core industries of China's digital economy, that is, use the text analysis method to subdivide the original innovation types and incremental innovation types of enterprises in this industry, and then obtain the current development level of these two innovation types of China's electronic information industry.

1. Measurement of original innovation in the core industries of China's digital economy

The original innovation is the first, breakthrough, extremely advanced, and an important starting source of technological innovation and development. Different from the literature that uses the number of patent applications and R&D investment to measure the original innovation of enterprises, this paper defines the new technology or product generated by the original innovation of industry as the technical words that appear in recent years or for the first time in the analyst report, and uses the text analysis method to measure the original innovation of electronic information industry.

This part selects the analyst reports published in the past five years within the above analysis scope, uses Python software to intercept the semantic context of words including "emerging", "development", "exploit" etc., and conducts manual identification and verification of the obtained results to find technical words that meet the definition of original innovation in recent years. Then take this as the measure of the electronic information industry original innovation development level (Table 1).

From the results we can see, the hot and emerging areas of the electronic information industry are integrated circuit industry, new display industry, big data, artificial intelligence, etc., among which household intelligence, chips, 5G, Web of Things and other words have gradually become emerging words in the electronic information industry in recent years.

Firstly, China's fifth generation mobile communication technology (5G) has been in the forefront of the world. As an important part of the 5G industry, words as communication

Table 1. Description of the original innovation in the analyst report (Part)

Target words	Products	Text description
Emerging	Micro and nano, optical communication, semiconductors, power devices	In MEMS and emerging markets, deep silicon etching equipment has been sold in batches to a number of scientific research institutions and production lines, serving many emerging fields such as micro and nano manufacturing, optical communications, compound semiconductors, and power devices……
Development	Intelligent security, AI, Web of Things	Under the trend of security AI, the company proposed the concept of AI Cloud in order to develop the Web of Things industry in the era of artificial intelligence, and defined the concept of AI CI……
	Optical fiber and cable	Fiber optic cable profits continue to improve, new business development momentum is good……
	Smart phones, AI, 5G, automotive electronics	Downstream innovative applications as smartphones, AI, 5G, and automotive electronics promote the sustainable development……
	Video, intelligent analytics, big data	The five emerging businesses are developing rapidly, and the company is expected to evolve into an intelligent analysis and big data company based on video information……
	Large-size LCD, flexible OLED	Large-size LCD and flexible OLED bring long-term development……
Exploit	Intelligent household appliance	For the development of U+ intelligent cloud platform and UHome OS intelligent home appliance operating system…… The company's vigorous expansion in smart home has been effective……
	Telescopic tube, conical tube	Has developed telescopic tubes, conical tubes, electronic tubes and other innovative products……
	Intelligent hardware, electronic information	Will carry out integrated joint development in intelligent hardware and electronic information core high-end basic components……
Prompt	Integrated circuit chip	Research and development of nanopilot processes…… China's IC chip manufacturing technology is developing rapidly……
New product	defense camera, intelligent cat eye	Also launched such as active defense cameras, intelligent cat eyes, humanoid detection cameras and other new products……
	400G Ethernet, 5G network	The continuous launch of new products such as 400G and 5G… Laying the foundation for future data center evolution to 400G……

equipment, optical fiber and cable, chips, and base stations are increasingly appearing in the text content, and are constantly developing with the innovation of 5G technology. More importantly, breakthroughs have been made in the development of 5G key technologies, and the independent research and development of key core technologies such as 5G chips and mobile operating systems has been successfully achieved. With Huawei's 5G mobile phone, many technologies in China have achieved breakthroughs from 0 to 1.

Secondly, other chip manufacturing fields have also produced fundamental breakthroughs: The analyst report shows that nanodiameter TSV (Through-Silicon-Via) deep silicon etching technology marking the development of China's advanced packaging process, which has promoted the development of linked multiple industries, such as micro and nano manufacturing, optical communications, compound semiconductors, and plays an important role in high-density integration. In addition, Integrated Circuit Chip (IC chips) has achieved 14nm to 7nm level microelectronic manufacturing process, which marks that China's integrated circuits will reduce energy consumption to a greater extent.

Finally, the development of Artificial Intelligence (AI) has promoted multiple fields into the era of intelligence. Firstly, speech recognition AI, is one of the most mature technologies in the field of AI in China, which maintains a leading position in computing power and AI data services. Secondly, AI security with visual recognition, like AI+ home security, AI+ community security and AI+ building security. Finally, AI+ meteorology, like Huawei Cloud Pangea Meteorological large model, proved the superiority of AI in weather forecasting.

In addition, above analyst report still mentioned the original innovation of other key products in the electronic information industry, such as the Web of Things, intelligent robots, new displays, etc., in which the product-related components and core technologies such as printed circuit board (PCB) high-density, filter miniaturization, and lightweight, and dual-camera technology have also been mentioned by analysts repeatedly. It can be seen that the electronic information industry is currently experiencing the overall innovation of the industry and products, the original innovation capacity of the industry has been significantly improved, emerging areas continue to emerge, and the research, development and production of new technologies and new products are constantly in progress.

2. Measurement of incremental innovation in the core industries of China's digital economy

According to the definition of incremental innovation, the incremental innovation in the electronic information industry is mainly reflected in the continuous and incremental innovation of existing products and technologies, from quantitative change to qualitative change, and finally achieve the overall innovation of the industry. Therefore, this paper defines the development of incremental innovation as the high-frequency product terms that appear most frequently in analyst reports of listed companies in the electronic information industry (Bloom et al., 2021). Based on the second section, the vocabulary of the vocabulary database is compared with the original analyst report to obtain the word frequency results of the entire industry's products in the research time frame of this paper, as a measurement of industrial incremental innovation.

As can be seen from the Table 2 results, in the analyst report from 2004 to 2023, products in the electronic information machine, electronic device, communication equipment industry have been mentioned by analysts many times. Conclusions can be drawn that:

Table 2. Incremental Innovation in Technology (Part)

Industrial classification	Product category	Frequency
Electronic information machine	Battery	220
Electronic special materials	Semiconductor	170
Communication equipment	Phone	137
Computer industry	Network	113
Electronic component	Relay	110
Electronic device	LCD	103
Electronic information machine	Optical fiber	90
Electronic device	Integrated circuit	89
Electronic information machine	Wirecable	79
Electronic information machine	Optical cable	78
Communication equipment	Communication device	57
Electronic device	Chip	49

Firstly, "Battery" has the highest frequency in the analyst report text, power batteries represented by lithium-ion batteries and lithium iron phosphate energy storage batteries have continuously achieved innovative breakthroughs, and some new products such as sodium-ion batteries, solid-state battery technology, cobalt-free batteries, and blade batteries have emerged. China's lithium battery technology is achieving the entire industry chain catch-up, breakthrough innovation reached a new height (Gong & Hansen, 2023), becoming a typical representative of the incremental innovation of China's digital core industry.

Secondly, LCD has become a high-frequency term mentioned by analysts in the electronic device industry products, all kinds of innovation in China's electronic display industry are bursting out, and it is currently in the leading position in the world by gradually imitating innovation "curve overtaking". China's display has gone through many stages -- from CRT, LED screen, LED TV screen, LCD, TFT-LCD, PDP plasma, OLED, AMOLED, etc., gradually developed to today's flexible OLED display technology. At present, China's TFT-LCD panel production capacity has ranked first in the world; TFT-LCD panel production line accounts for more than 80% of the world's construction and planning; In addition, China's OLED display technology has gradually become a new breakthrough in the field of screen display.

Finally, the field of Information and communication has achieved domestic substitution, optical fiber and cable development has entered a new stage. Words such as optical fiber, optical cable and wirecable have become high-frequency words in the electronic information industry. At present, China has launched a series of new products and technologies including ultra-low loss optical fiber, ultra-large capacity optical fiber, special optical cable, submarine cable, optical device, optical module, etc., and has achieved innovative breakthroughs in the realization of 5G new optical cables, mass production of 400G and 800G optical modules, and independent research and development of MESH networks.

In addition, the incremental innovation of products such as air conditioners, integrated circuits, and smart hardware chips also plays a non-negligible role in realizing the development and application of technologies such as artificial intelligence, wearable devices, and the Internet of Things (IoT). It is worth noting that among the measurement results of words related to incremental innovation, words related to battery, relay, semiconductor, mobile phone, etc. are consistent with the words that constitute the overall innovation mentioned above. It can be seen that incremental innovation is an important part of the overall innovation. Words related to integrated circuits, fiber optic cables, 5G, and high-definition displays are consistent with original innovations, indicating that the electronic information industry is not only innovating existing technologies in these fields, but also actively developing new products.

3. Sum up

Based on above, the core industry of China's digital economy is currently in a vigorous trend of innovation and development, achieving breakthroughs from 0 to 1 and making technological improvements and innovations in a number of existing fields. However, there are still many risks and challenges: First of all, there is still some gap between China's original

innovation ability and the world's advanced level in some key areas of the digital economy, which is specifically reflected in the "bottleneck" problem of its core technology. Secondly, due to the late start of China's electronic information industry, the innovation of key products and key technologies in some industries still needs to imitate foreign advanced technologies. Finally, there is still a large gap between the R&D investment of China's electronic information industry and that of developed countries, which is due to the scientific and technological innovation in the industry is still in the early stage. Therefore, China still has a long way to go to achieve scientific and technological self-reliance in the field of digital technology.

4. Conclusion

As the world's most active, most dynamic and most permeable field of innovation, the digital economy is becoming an important driving force for economic and social development in today's world. The level of innovation in the core industries of China's digital economy and how to overcome the limitations of traditional methods of measuring innovation are theoretical and practical problems that need to be solved urgently. Therefore, this paper uses the method of text information mining to measure the overall innovation trend and innovation subdivision types of the core industry of China's digital economy. The method of text information mining provides a better measurement method for the innovation measurement of enterprises without patent applications and R&D investment in the study time domain, and it develops a new measurement method in expanding the sample of enterprises including innovation (Bellstam et al., 2020). Using this innovative measurement method to analyze the text content, it is found that: In terms of overall innovation, China's digital core industry is currently showing the characteristics of rapid progress and other original innovations burst out, the incremental innovation and integration of self-developed disruptive technologies has experienced "curve overtaking". However, we cannot ignore the reality that China's digital technology core industry still has limited enterprise technical capacity accumulation, collaborative innovation mechanism and system is still imperfect, and the problem of "stuck neck" in key core areas is still prominent.

Although this paper uses text analysis to measure and analyze the overall innovation and innovation types of the core industries of China's digital economy, it is still insufficient to explore the key factors affecting the innovation of the core industries of the digital economy, and its clearer path of promotion remains to be studied.

Conflict of interest: none.

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The Carbon Reduction Effect of Green Finance: Based on the Evaluation of the Effect of China's Green Finance Reform and Innovation Policies

Tianjiao ZHANG, Guiyi ZHU, Xiaolan LI, Junli LIU, Mengfan DUAN, Peizhen CHEN, Beibei SHI and Rong KANG*

School of Economics and Management, Northwest University, Xi'an, China; zhang_tianjiao2022@163.com; zhuguiyi@stumail.nwu.edu.cn; Xiaolan_li0920@163.com; 1934376847@qq.com; 3485250834@qq.com; 1659843185@qq.com; shibeibei@nwu.edu.cn; kangrong@nwu.edu.cn

* Corresponding author: kangrong@nwu.edu.cn

Abstract: Using green finance to promote developing countries to achieve carbon emission reduction is an effective path for developing countries to fulfill their emission reduction responsibilities in the process of coping with global climate change. In view of this, this paper takes the development of China's green finance as the research object, uses the data of China's city level and enterprise level from 2009 to 2020, and uses the difference-difference method to evaluate the impact of green finance reform and innovation policies on carbon emissions and explore its internal mechanism. The results show that the implementation of GFRI policies can significantly promote urban carbon emission reduction. The mechanism test shows that the implementation of the GFRI policy has promoted the significant increase of green investment in pilot cities, especially in heavily polluting enterprises. At the same time, the implementation of the GFRI policy has also promoted green technology innovation, but there is a "decoupling" of the quantity and quality of innovation. It is further found that the emission reduction effect of green finance has significant industry "spillover effect".

Keywords: green finance reform and innovation policy; carbon reduction; green investment; spillover effect

JEL Classification: Q56; G1; O32

1. Introduction

With the rapid development of global economy and the continuous expansion of population size, human resource consumption and energy consumption continue to increase, and climate change problems such as sea level rise, global warming, air and soil pollution come into being (Datta et al., 2022). Climate change is the most serious challenge facing mankind, and actively responding to climate change has become the consensus of all mankind. However, due to the needs of economic development, the use of breakthrough technologies in developing countries must be at the cost of consuming a large amount of energy such as electricity, coal and oil, which in turn leads to a large amount of carbon emissions and the threat of environmental problems such as climate change (Hu, 2023). As a major carbon emission country, China is facing enormous pressure to reduce emissions. The high pollution of the environment not only leads to the reduction of social welfare, but also

causes certain losses to economic development. Therefore, China urgently needs to make carbon emission reduction efforts, and China's commitment to peak carbon neutrality reflects the determination of developing countries represented by China to reduce carbon emissions.

Finance is the core of modern economy, and green finance plays an important role in promoting green and low-carbon transformation of economic structure and mitigating climate change risks (Zhao & Liu, 2020; Ameli et al., 2021). In fact, China's green finance policy has made steady progress in recent years. Especially in 2017, China decided to build a green finance reform and innovation pilot zone, which organically combines "top-down" policy promotion with "bottom-up" reform and innovation, and provides a series of replicable and scalable experiences for the development and improvement of the green finance system. China's outstanding green loans in local and foreign currencies reached 22.03 trillion yuan, a year-on-year increase of 38.5% and an increase of 6.01 trillion yuan for the whole year. In addition, China's green finance market is gradually expanding, green funds, ESG investment (Environmental, Social, Governance), green insurance are developing rapidly, and a variety of innovative green financial products and low-carbon practices are emerging. This "up-down linkage" approach helps to promote the optimization and adjustment of industrial structure and energy efficiency, and achieve the goal of reaching peak carbon neutrality. Therefore, it is of practical significance to explore the carbon emission reduction effect and transmission path brought about by green finance reform and innovation policies in this context.

Compared with the existing literature, the marginal contribution of this paper is as follows: From the perspective of research, it takes the green finance reform and innovation policy (GFRI policy) as an example to evaluate the carbon emission reduction effect of green finance, which helps to supplement the research results of the existing scholars on green finance. In terms of mechanism analysis, firstly, from the perspective of green investment, the carbon emission reduction effect of green finance reform and innovation policy is explored from both macro regions and micro enterprises. Secondly, from the perspective of green technology innovation, the paper explores whether green finance reform and innovation policy can achieve carbon emission reduction by means of "quality and quantity preservation" of green technology innovation, which enriched the path of carbon emission reduction of green finance in the academic circle. In terms of thinking path, this paper uses micro-enterprise data to further analyze the carbon emission reduction effect of GFRI policy, and discusses the industry spillover of carbon emission reduction effect of key and non-key industries supported by green finance reform and innovation policy. In addition, on this basis, it also sorts out the industries that are most and least impacted by green finance reform and innovation policy.

2. Methodology

Most countries and regions are experiencing the development and reform of the financial industry, and the rapid development of the financial industry will promote economic development, which is closely related to regional carbon emissions. GFRI policies can promote the transformation of regional economic growth mode to green by guiding funds to

resource-saving green projects to achieve carbon emission reduction targets. Based on this, this paper puts forward the following hypothesis.

Hypothesis 1: Green finance reform and innovation policies can effectively reduce regional carbon emissions.

The implementation of green projects or the realization of enterprises' emission reduction targets will promote the green and coordinated development of the economy and further promote eco-friendly growth (Rogge & Schleich, 2018). Green investment is one way to achieve these goals. However, energy conservation and emission reduction can improve efficiency and save money, and reduce pollution will increase the cost of enterprises. The implementation of the green finance reform and innovation policy has alleviated the financing constraints of enterprises in terms of financing costs and financing methods, and the expansion of financing scale has actively promoted enterprises to make green investment and realize comprehensive low-carbon transformation.

As a general term for technologies, processes or products that can reduce environmental pollution and energy consumption, green technology innovation is undoubtedly one of the key factors to promote high-quality green development of the economy (Braun & Wield, 1994; Su et al., 2020). GFRI policies provide capital allocation to enterprises from the inside, and create favorable conditions for enterprises' green innovation activities from the outside through risk control and competition incentives, so as to expand the innovation compensation effect generated by the market mechanism.

Hypothesis 2: Green finance reform and innovation policies reduce carbon emissions by increasing corporate green investment and green technology innovation.

The realization of effective carbon emission reduction in a region mainly depends on the behavior of enterprises, and carbon emission reduction involves many decisions. If these decisions are made by a single enterprise, it is difficult to unify the carbon emission reduction activities of all enterprises. Obviously, only by comprehensively considering the distribution of carbon emission reduction in the supply chain can the optimal effect be achieved. Green finance reform and innovation policies can provide long-term and low-cost funds, help balance the risks and benefits of carbon emission reduction for enterprises (Lin & Teng, 2022). Based on this, this paper puts forward the following hypothesis.

Hypothesis 3: The carbon emission reduction effect of green finance reform and innovation policies has significant "spillover effect" between industries.

In summary, based on the relationship and influence mechanism between green finance reform and innovation pilot zone and carbon emissions, this paper makes the above assumptions, and the path is shown in Figure 1.

This paper focuses on the emission reduction effect of green finance development, so the measurement of carbon dioxide is the focus of our attention. In order to measure carbon emissions more comprehensively, this paper calculates carbon emissions accurately from the
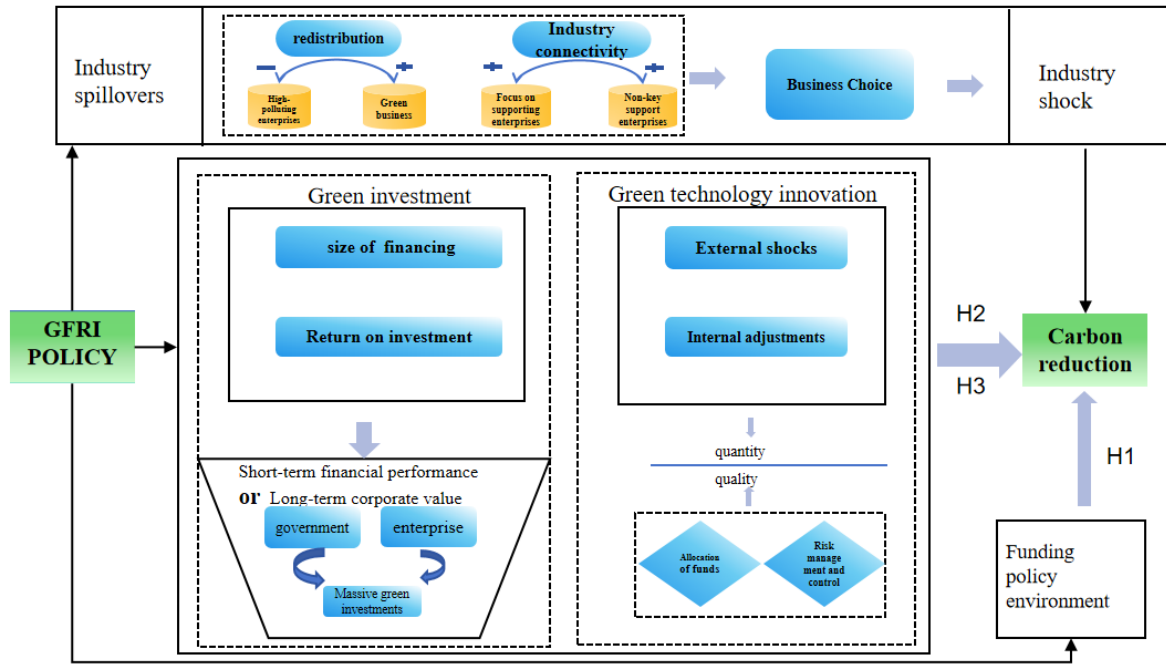
Figure 1. The interaction path between green finance and carbon emission reduction

city level (formula (1)) and the enterprise level (formula (2)). At the city level, urban carbon dioxide emissions (CO2) and per capita carbon dioxide emissions (perCO2) were selected as explained variables, respectively. The carbon emission calculation formula is as follows:

$$CO_2 = ad \times ef_1 + ec \times ef_2 + (Q_{consume} + Q_{revenue}) \tag{1}$$

$$TC = ad_{enterprise} \times ef + ec_{enterprise} \times ef \tag{2}$$

CO2 and TC is the total carbon dioxide emission, ad is the activity level data of the fossil fuel consumed by the city and enterprise respectively, and ef1 is the emission factor of the fossil fuel by the city and enterprise respectively, ec is the purchased electricity of the city and enterprise respectively, and ef2 is the emission factor calculated by the average power grid of the region where the city and enterprise are located. $Q_{consumption}$ is the carbon dioxide produced by consumption, $Q_{revenue}$ is the carbon dioxide produced by revenue.

In this paper, the implementation of green finance reform and innovation policy in 2017 is taken as an external impact to construct a quasi-natural experiment, and the effect evaluation is carried out using differential difference. Therefore, the core explanatory variable of this paper first takes the implementation of the green finance reform and innovation policy in 2017 (GFRI policy) as the explanatory variable. If the city implements the green finance reform policy in 2017 and later, the value is 1, and if the city implements the green finance reform policy in 2017 and before, the value is 0. Area is the virtual variable of the pilot area. If the area is in the pilot area, the value is 1. In non-pilot areas, the value is 0. Furthermore, in order to measure the intensity of the policy implementation, we selected the Green Credit Index (GFRI policy_credit), Green Insurance Index (GFRI policy_insurance), Green Bond Index (GFRI policy_bond), and Green Fund Index (GFRI policy_funds) of pilot cities after 2017 as explanatory variables. Among them, the green credit index is calculated by the proportion of total

credit of regional environmental protection projects in total credit, the green insurance index is calculated by the proportion of regional environmental pollution liability insurance income in total premium income, and the green bond index is expressed by the proportion of total regional green bond issuance in total bond issuance. The Green Fund Index is expressed as a proportion of the total market value of regional green funds to the total market value of all funds.

This paper selects two mechanism variables of green investment and green technology innovation to explore the effect of green finance reform and innovation policies on urban carbon emissions.

By comparing the differences of carbon emissions between pilot cities and non-pilot cities before and after the implementation of green finance reform and innovation policies, the net effect of policy implementation on carbon emissions in pilot areas is identified. The following model is constructed:

$$CO_{2it} = \alpha_0 + \alpha_1 GFRI\ policy_{it} + \rho X_{it} + \delta_i + \gamma_t + \varepsilon_{it} \tag{3}$$

In the above formula, CO_{2it} is the carbon emission and per capita carbon emission in year t of region i; The core explanatory variable $GFRI\ policy_{it}$ includes the implementation of the Green Finance Reform Innovation policy (GFRI policy) in 2017 and the intensity of the implementation of the policy. Specific for the pilot cities after 2017 green credit index (GFRI policy_credit), green insurance index (GFRI policy_insurance), green bond index (GFRI policy_bond), Green Fund index (GFRI policy_funds). α_0 is the constant term, and α_1 is the doubled-difference estimate, which is the focus of this paper. X_{it} is a set of control variables that affect urban carbon emissions. ρ is the coefficient that controls the variable. δ_i represents the city fixed effect, γ_t represents the year fixed effect, and ε_{it} represents the random disturbance term.

$$Me_{it} = \beta_0 + \beta_1 GFRI\ policy_{it} + \phi X_{it} + \vartheta_i + \varpi_t + \sigma_{it} \tag{4}$$

In the above formula, Me_{it} is the mechanism variable, including enterprise green investment, proportion of enterprise green investment, number of enterprise green patent applications, number of enterprise green patent citations, and proportion of enterprise green patent authorization in the number of green patent applications. β_0 is the constant term, β_1 is the interaction term coefficient, which is the coefficient concerned in this paper, ϕ is the coefficient that controls the variable. ϑ_i、 ω_t and σ_{it} are the regional fixed effect, the year fixed effect and the random disturbance term respectively, and the other variables are the same as (1).

3. Results

3.1. Baseline Regression

This paper first examines the impact of green finance reform and innovation policies on carbon emissions. We perform regression on model (1), and the specific results are shown in Table 1. Table 1 shows the regression results of model (1) green finance reform and innovation policy as the core explanatory variable. The results in Table 1 show that GFRI policy significantly reduces regional carbon emissions. Columns (1) and (2) in Table 1 are

regression results of urban carbon emissions as explained variables. The coefficients of GFRI policy in these two columns are -0.210 and -0.413, which are significant at the 5% confidence level. Column (3) and (4) listed regional per capita carbon emissions are regression results of explained variables, and the coefficients of GFRI policy are -1.001 and -1.082, which are significant at the 1% level, indicating that green finance reform and innovation policies are conducive to promoting carbon emission reduction. Hypothesis 1 is verified.

Table 1. Impacts of green finance reform and innovation policies on urban carbon emissions

	(1) CO2	(2) CO2	(3) perCO2	(4) perCO2
GFRI policy	-0.210**	-0.413**	-1.001***	-1.082***
	(0.100)	(0.191)	(0.347)	(0.416)
Constants	3.111***	1.607	10.263***	25.872**
	(0.073)	(3.823)	(0.132)	(12.145)
Controls	YES	YES	YES	YES
Observations	4,560	1,289	3,458	1,289
F	31.641	11.572	19.207	9.964
R-squared	0.190	0.685	0.180	0.245

Note: Robustness standard errors are in parentheses; ***, ** and * represent significance levels of 1%, 5% and 10% respectively. The fixed effects of year and individual are controlled.

In addition to examining the implementation of green finance reform and innovation policies in Table 1, this article attempts to characterize the intensity of policy implementation by selecting the pilot city green credit index (GFRI policy_credit), green insurance index (GFRI policy_insurance), green bond index (GFRI policy_bond), and green fund index (GFRI policy_funds) as explanatory variables to regress model (1), as shown in Table 2. As can be seen from Table 2, the overall intensity of policy implementation has a significant promoting effect on carbon emission reduction.

Table 2. Impacts of green finance reform and innovation policies on urban carbon emissions

	(1) CO2	(2) CO2	(3) CO2	(4) CO2	(5) perCO2	(6) perCO2	(7) perCO2	(8) perCO2
GFRI policy_credit	-9.164**				-2.052**			
	(4.962)				(0.936)			
GFRI policy_insurance		-1.024***				-2.785***		
		(0.476)				(0.472)		
GFRI policy_bond			-1.480**				-7.795**	
			(0.834)				(3.831)	
GFRI policy_funds				-1.340***				-3.138***
				(0.479)				(1.333)
Constants	3.905**	4.129**	3.647*	3.243	33.428***	33.499***	33.318***	30.679***
	(1.795)	(1.875)	(1.976)	(1.987)	(10.783)	(10.810)	(11.065)	(11.024)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	936	936	936	936	936	936	936	936
F	43.436	38.664	45.236	37.842	55.673	54.583	41.253	35.633
R-squared	0.531	0.512	0.482	0.503	0.664	0.664	0.659	0.659

Note: Robustness standard errors are in parentheses; ***, ** and * represent significance levels of 1%, 5% and 10% respectively.

3.2. Mechanism Analysis

1. Impact of Green Financial Reform and Innovation Policies on Green Investment

One of the objectives of implementing green financial reform policies is to increase green investment in pilot cities, thereby achieving environmental benefits. This paper selects the database of listed companies from 2000 to 2020 and measures a company's green investment based on the amount of green investments and its proportion in total investment. Regression analysis is performed according to Model (2), and the results are shown in Table 3. Based on the analysis of Table 3, from the perspective of all companies in columns (1) and (4), both the total amount and proportion of green investment by companies are significantly positive. Given that heavily polluting companies are more affected by the GFRI policies, the sample is divided into two categories: heavily polluting and non-heavily polluting companies. Columns (2) and (5) show that both green investment amount and proportion of green investment are significantly positive for heavily polluting enterprises, indicating that GFRI policies have a greater promoting effect on the greening of heavily polluting enterprises. On the other hand, columns (3) and (6) indicate that the regression coefficients for non-heavily polluting companies are not significantly positive, suggesting that the GFRI policy does not have a significant role in affecting non-heavily polluting companies.

Table 3. Analysis of the mechanism for realizing carbon emission reduction through green financial reform and innovation policies

	Amount of green investments			Percentage of green investments		
	(1)	(2)	(3)	(4)	(5)	(6)
	All companies	Heavily polluting companies	Non-heavily polluting companies	All companies	Heavily polluting companies	Non-heavily polluting companies
GFRI policy	0.345**	0.538***	0.154	0.263**	0.401**	0.180
	(0.188)	(0.193)	(0.281)	(0.187)	(0.192)	(0.278)
Controls	YES	YES	YES	YES	YES	YES
Constants	14.823***	15.357***	14.314***	-6.078***	-5.715***	-6.440***
	(0.291)	(0.316)	(0.528)	(0.334)	(0.277)	(0.595)
Observations	2,205	1,077	1,118	2,205	1,077	1,118
F	7.218	18.126	5.567	2.959	5.799	3.728
R-squared	0.224	0.193	0.262	0.166	0.117	0.233

Note: Robustness standard errors are in parentheses; ***, ** and * represent significance levels of 1%, 5% and 10% respectively. The fixed effects of year, individual and industry are controlled.

2. Impact of Green Financial Reform and Innovation Policies on Enterprises' Green Technological Innovation

The implementation of GFRI policies aims to compensate for the funding required for environmental governance during the development of the real economy. Therefore, by expanding the allocation of financial resources, it can alleviate the funding constraints faced by enterprises in technological innovation and stimulate their enthusiasm for participating in green technology innovation activities. In view of this, this section will focus on analyzing the impact of GFRI policies on enterprise green technology innovation, and conduct regression analysis on the total number of patents and the number of green patents for enterprises based

on Model (2), as shown in Table 4. It can be seen that the total number of patents in column (1) and the number of green patents in column (2) both increased significantly, indicating that the implementation of green finance reform and innovation policies significantly increased the number of green technology innovations by enterprises. Specifically, the regression coefficient for non-heavily polluting enterprises was not significant, which may be due to the relatively sufficient financing channels and financial support for non-heavily polluting enterprises, resulting in a lack of sufficient motivation for green technology innovation.

Table 4. Analysis of the mechanism of green investment for realizing carbon emission reduction through green financial reform and innovation policies

	Total number of patents	Number of green patents		
	(1)	(2)	(3)	(4)
	All companies	All companies	Heavily polluting companies	Non-heavily polluting companies
GFRI policy	0.181***	0.035***	0.084**	0.014
	(0.059)	(0.013)	(0.049)	(0.043)
Constants	2.027***	0.593***	0.377***	0.720***
	(0.149)	(0.026)	(0.115)	(0.088)
Controls	YES	YES	YES	YES
Observations	17,984	33,785	12,447	21,338
F	46.214	980.962	38.332	10.418
R-squared	0.264	0.358	0.376	0.356

Note: Robustness standard errors are in parentheses; ***, ** and * represent significance levels of 1%, 5% and 10% respectively. The fixed effects of year, individual and industry are controlled.

Table 5. Analysis of the mechanism of green technology innovation for realizing carbon emission reduction through green financial reform and innovation policies

	All companies	Heavily polluting companies	Non-heavily polluting companies	All companies	Heavily polluting companies	Non-heavily polluting companies
	(1)	(2)	(3)	(4)	(5)	(6)
	Number of citations to green patents in the last five years			Green Patent License/Green Patent Application		
GFRI policy	-0.065***	-0.106*	-0.045	-0.493**	-0.437**	-0.487**
	(0.032)	(0.060)	(0.031)	(0.198)	(0.179)	(0.231)
Constants	0.877***	1.005***	0.806***	1.347***	0.986***	1.492***
	(0.092)	(0.087)	(0.072)	(0.404)	(0.365)	(0.492)
Controls	YES	YES	YES	YES	YES	YES
Observations	4,257	1,666	2,591	7,041	2,504	4,537
F	5.549	1.329	9.358	14.851	19.868	20.661
R-squared	0.281	0.219	0.333	0.216	0.260	0.203

Note: Robustness standard errors are in parentheses; ***, ** and * represent significance levels of 1%, 5% and 10% respectively.

With the greening of the product market, the innovation of green technology can bring greater profits to the enterprise. This "profitability" is likely to become a driving force for enterprises' "greenwashing" behavior, leading them to be more inclined to increase the

Table 6. Inter-industry carbon emission reduction spillover effects under green financial reform and innovation policies

	Key supported industries of green finance										Non-Key supported industries of green finance									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(19)	(20)	(21)
	CO_2	tCO_2	CO_2	CO_2	CO_2	CO_2	tCO_2	tCO_2	tCO_2	tCO_2	CO_2	tCO_2	CO_2	CO_2	CO_2	CO_2	tCO_2	tCO_2	tCO_2	tCO_2
GFRI policy	-0.081**	-0.081**									-0.056***	-0.056***								
	(0.037)	(0.037)									(0.020)	(0.020)								
GFRI policy_credit			-1.053**				-1.053**						-1.250**				-1.250**			
			(0.924)				(0.924)						(0.563)				(0.563)			
GFRI policy_insurance				-0.032**				-0.032**						-0.105*				-0.105*		
				(0.091)				(0.091)						(0.056)				(0.056)		
GFRI policy_bond					-0.174**				-0.174**						-0.279*				-0.279*	
					(0.247)				(0.247)						(0.148)				(0.148)	
GFRI policy_funds						-0.130***				-0.130***						-0.099**				-0.099**
						(0.089)				(0.089)						(0.055)				(0.055)
Observations	4,925	4,925	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971	14,085	14,085	14,085	5,324	5,324	5,324	5,324	5,324	5,324	5,324
F	274.201	63.554	120.163	119.933	120.141	120.753	62.074	61.887	62.056	62.553	923.031	115.972	923.031	248.815	248.430	248.334	248.226	56.207	55.919	55.848
R-squared	0.870	0.543	0.909	0.909	0.909	0.909	0.643	0.643	0.643	0.644	0.882	0.551	0.882	0.884	0.884	0.884	0.884	0.561	0.560	0.560

quantity of green technological innovations without giving much consideration to their quality in order to meet public expectations of green environmental protection. To detect whether enterprises engage in "environmental fraud," this paper conducts regression analysis on the quality of enterprise green technology innovation based on Model (2), and the results are shown in Table 5. We found that the regression coefficient for the quality of green innovation for all enterprises decreased significantly.

4. Discussion

To verify the differences in carbon emission reduction effects and industry spillover effects of green finance reform and innovation policies on various industries, we conducted regression analysis based on Model (1) for both key supported industry enterprises and non-key supported industry enterprises, after screening for a list of key supported industries under the green finance reform and innovation policy. The regression results are shown in Table 6. Analysis of the results indicates that the regression coefficient for enterprises belonging to key supported industries under the green finance reform and innovation policy is significant at the 5% confidence level, demonstrating a significant inhibitory effect of green finance reform and innovation policies on carbon emissions for green industry enterprises. Meanwhile, the regression coefficient for non-key supported industries is significant at the 1% confidence level but with a relatively smaller effect coefficient, indicating the existence of an industry spillover effect.

The development of GFRI policies can screen out leading green industries. Therefore, this paper conducts regression analysis based on Model (1) for enterprises in different industries, as shown in Table 7. It can be observed that the industries most impacted by GFRI policies are concentrated in the construction, textile, transportation, manufacturing, and processing industries. These industries have long relied on fossil energy sources for their survival and development, and their related production technologies, infrastructure, and industrial systems are adapted to fossil energy, resulting in a "high-carbon lock-in" for some

Table 7. Impact of green finance on different sectors

	Industry	Coefficient	Standard error	Observations
Five industries with the greatest impact	E50 Building decoration and other construction industries	-0.4505**	(0.2563)	198
	G54 Road transport industry	-0.2890**	(0.1144)	420
	C37 Railway, shipbuilding, aerospace and other transportation equipment manufacturing	-0.2196***	(0.1107)	575
	C13 Agricultural and sideline food processing industry	-0.2113**	(0.0934)	463
	D44 Electricity, heat production and supply industry	-0.2073**	(0.0995)	861
The four sectors with the least impact	C14 Food manufacturing	-0.1961**	(0.0909)	489
	K70 Real estate	-0.1912***	(0.0975)	1,356
	C39 Computer, communications and other electronic equipment manufacturing	-0.1644***	(0.0484)	3,319
	C35 Automotive manufacturing	-0.1402***	(0.0439)	1,968

Note: Robustness standard errors are in parentheses; ***, ** and * represent significance levels of 1%, 5% and 10% respectively.

industries and making carbon emission reduction difficult for them. However, GFRI policies can not only provide policy and economic support for these industries, but the existence of environmental disclosure systems can also force industries to transition towards green development. The combined effect of these two factors leads to significant carbon emission reduction effectiveness in these industries. On the other hand, the industries with the least impact are mostly high-end manufacturing and service industries. These industries often have higher technological levels, larger financing scales, stronger talent pools, and higher self-advantages, allowing for faster transformation and the carbon emission reduction effect of the impact of GFRI policies is very small.

5. Conclusions

The research results show that the implementation of green finance reform and innovation policies can significantly promote urban carbon emission reduction. Mechanism tests show that the implementation of green finance reform and innovation policies has promoted a significant increase in green investment in pilot cities, especially for heavily polluting enterprises. At the same time, the implementation of this policy has also promoted green technological innovation, but led to a decrease in the quality of green innovation, with a "decoupling" of innovation quantity and quality. Further, it is found that the emission reduction effect of green finance can not only achieve carbon emission reduction in capital-intensive industries, but also achieve carbon emission reduction in non-capital-intensive industries, with significant industry "spillover effects".

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University of Hradec Králové
Faculty of Informatics and Management