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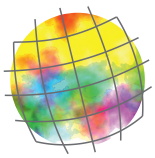

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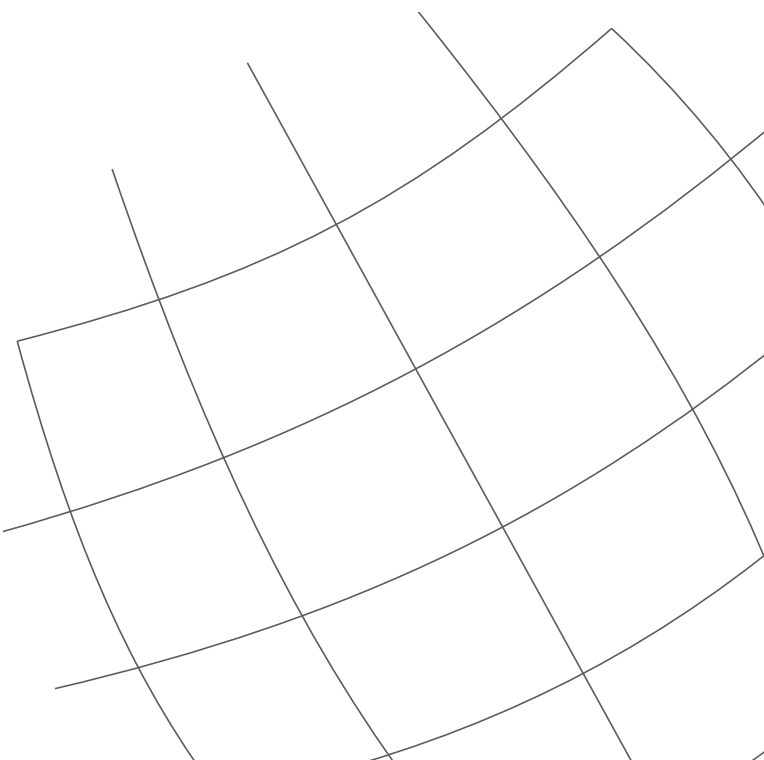

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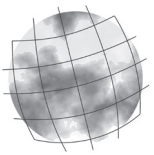

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# CONTENT

# DEVELOPMENT PROSPECTS OF RURAL TOURISM ALONG THE DANUBE
## Key Factors of Satisfaction and the Role of Sustainability

**Aranka BOROS[A*], Enikő KORCSMÁROS[B]**

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**Abstract**
This study examines the factors influencing visitor satisfaction in rural tourism within the Danube region, a significant area for sustainable tourism in Central and Eastern Europe. The research aims to assess the impact of sustainability practices, corporate social responsibility (CSR) initiatives, service quality, and demographic factors on tourist satisfaction, motivated by the growing emphasis on sustainability aligned with the EU Strategy for the Danube Region (EUSDR). A quantitative approach was employed, using an online survey distributed in Hungarian and Slovak to ensure inclusivity. Snowball sampling resulted in 255 valid responses from tourists familiar with the region. Data analysis included Chi-square tests, Spearman's rank correlation, Wilcoxon signed-rank tests, and multiple linear regression, using Microsoft Excel for data coding and SPSS software for in-depth statistical analysis. The findings suggest that a majority of respondents perceive a need for improvement in sustainability practices, while many consider CSR initiatives to have a significant influence on their overall satisfaction. A positive correlation was found between awareness of sustainability initiatives and service preferences. Disparities emerged between perceived and expected service quality. Regression analysis identified expectation-shaping factors and facility satisfaction as key predictors of overall satisfaction, with no significant impact from price-value perceptions. This study contributes to rural tourism literature by integrating sustainability perceptions, service quality, and demographics into a comprehensive satisfaction model. The findings provide empirical insights for enhancing service quality and adopting sustainable practices, supporting the EUSDR's objectives. Future research could expand the scope by including additional regions or employing a larger sample size to validate the findings further and provide a broader understanding of satisfaction determinants in rural tourism.

**Key words**
Danube region, rural tourism, sustainability, social responsibility, service quality, satisfaction.

## INTRODUCTION

The European Union Strategy for the Danube Region (EUSDR) covers the Danube Basin, stretching from Germany to the Black Sea, involving 14 countries, including 9 EU member states and 5 non-EU countries. The Danube region offers significant potential for the development of rural tourism, which is crucial for achieving the EU's territorial cohesion objectives. In Slovakia, the region possesses outstanding cultural and natural values, whose sustainable tourism utilization can enhance the economic stability of local communities. The region's transboundary nature fosters international cooperation, supporting environmental and social goals through sustainability efforts in tourism development (European Commission, online; Jászberényi, 2019). However, for this development to be sustainable, it is essential to meet visitor needs and ensure their satisfaction. This includes improving the quality of services, preserving cultural and natural attractions, and enhancing infrastructure to ensure that tourists have positive experiences and are encouraged to return to the region.

Recent studies have highlighted the significant role of tourism in regional development. Identifying tourism core areas, for instance, through the Tourism Penetration Index (TPI), can effectively pinpoint locations with considerable tourism potential (Bujdosó et al., 2019). Similar measures in the Slovak part of the Danube region would significantly improve efforts of sustainable tourism, particularly in areas where cultural and natural values meet. According to Mousazadeh (2022), proximity to natural amenities-like the Danube River-significantly contributes to an increase in well-being and satisfaction among residents. Particularly, such findings contribute to the enhancement of rural development in the Slovak Danube region, which possesses huge potential for further advancement of rural tourism. It is mostly represented by the Hungarian minority-inhabited areas, incorporating a rich historical heritage, diverse relief, and, correspondingly, numerous tourist attractions: the Danube River, its tributaries, thermal waters, floodplain woodlands of different ecological types, as well as cultural and historical objects. The region's gastronomic offerings, blending local traditions with international influences, also carry significant tourism potential (Michaeli, 2015; Nagy, 2018; Országová, 2020; Lacika, 2006; Kerekeš, 2019; Kasagranda et al., 2016; Bizubová and Kollár, 2000; Gúčik, 2010). The cross-border nature of the region facilitates international cooperation and the implementation of sustainability efforts, ensuring that tourism development supports environmental and social goals in the long term. Despite its strengths, the region faces challenges such as infrastructure limitations and environmental concerns. Local governments and service providers are increasingly focusing on sustainability, striving for environmentally friendly solutions and the preservation of local culture (Hrubalová, 2015; Kádár and Vitková, 2019; Vitková and Štrbíková, 2021). The rapid growth and widespread expansion of modern tourism occurred within a relatively short time frame. While only 25 million

people participated in international travel in the early 1950s, by 2019 this number had surged to 1.4 billion (Gonda, 2022; UNWTO, 2019). Although this growth brings significant economic benefits, such as job creation and the development of local communities, it also poses serious challenges for nation-states and society (Jarábková et al., 2021). The tourism sector is responsible for approximately 8% of global carbon emissions (Ásványi, 2022), making it a substantial contributor to climate change (Streimikiene et al., 2020).

The relationship between service quality and tourists' expectations is pivotal in shaping the overall tourism experience. Numerous studies have highlighted significant discrepancies between perceived service quality and tourists' expectations (Lo et al., 2010; Abdou et al., 2022). This issue is particularly relevant in rural tourism, where service providers often face challenges due to limited resources and evolving market demands (Al Matris, 2023; Żemła & Szromek, 2023; Iwara, 2023; Dreshaj et al., 2022). Service quality perception is not fixed; it is dynamic and subjective. Individual perceptions of the quality of service are influenced by cognitive and affective factors, which determine which attributes come into sharp focus and attain importance. The cognitive aspects, such as experiences and learned expectations, interact with the affective elements – emotional reactions to the service encounter – that often play a decisive role regarding overall satisfaction (Wirtz & Lovelock, 2016; Ronnie & Philip, 2021). Identity and image studies explain that while a service provider works toward a specific brand identity, the final image is filtered through individual factors such as socio-economic status, cultural heritage, and personal beliefs. Individual experiences and broader socio-economic contexts, such as income disparity or educational background, result in variations in how service quality is perceived. Various external elements, including cultural norms and local customs, significantly influence how services are perceived (Mousazadeh, 2022; Uslu et al., 2020; Singh et al., 2020). The concept of "polycrisis," which refers to the intersection of multiple simultaneous crises - such as economic, social, and environmental challenges - profoundly impacts tourists' expectations and service requirements. Polycrisis describes how these crises interact, ultimately influencing tourists' perceptions of service quality (Matlovič, 2008; Matlovič & Matlovičová, 2024; Pogátsa, 2023; Tsao & Ni, 2016; Saniuk et al., 2020). The cumulative impact of these challenges has heightened the emphasis on sustainability and ethical practices in service provision, thereby altering what tourists now view as indicators of high-quality service (Chapin et al., 2010). Consequently, rural tourism service providers must not only focus on the products they offer but also on how they communicate value in response to changing consumer priorities. Tourists' previous expectations significantly affect their travel experiences and satisfaction (Rodríguez del Bosque, 2006; Ye et al., 2019; Fu et al., 2020; Mortazavi, 2021; Stylidis et al., 2022; Intani & Rojuaniah, 2024). In the Danube region, addressing the area's varied cultural and natural

features is vital, as they contribute to a broad spectrum of visitor expectations. Recent research underscores the importance of customizing tourism services to cater to the differing experiential desires of various tourist groups. According to Pellešová and Vacha (2023), integrating novel experiences, like emerging trends in gastronomy, has a significant impact on enhancing visitor satisfaction. Similarly, Herman et al. (2020) emphasize that strong collaboration between stakeholders is vital for bolstering tourism infrastructure. Such cooperation can effectively support the region's diverse tourism offerings, fostering sustainable development while helping to smooth out seasonal fluctuations.

## OBJECTIVES

The research aimed to achieve several specific objectives. Firstly, it sought to examine the role of sustainability practices and corporate social responsibility (CSR) initiatives in shaping overall tourism satisfaction. Secondly, the study aimed to analyse the discrepancies between customer expectations and the perceived quality of service within rural tourism offerings. Finally, the research aimed to identify the critical factors that influence customer satisfaction specifically in rural tourism within the Danube region. These objectives were designed to provide a comprehensive understanding of the dynamics impacting tourist experiences and satisfaction, with a particular emphasis on sustainability and service quality.

Our research focuses on the Danube region in Slovakia, examining the drivers of tourist experiences to gain a deeper understanding of the dynamics and development opportunities of rural tourism. The findings highlight the connections between service quality and sustainability efforts, which strengthen the economic stability of local communities and provide a model example at an international level for other similar regions. In terms of contributing to solving rural challenges, this research can help identify areas where service quality requires improvement and highlight opportunities for sustainable tourism development. Additionally, the results may contribute to the economic revitalization of rural areas and the enhancement of service quality.

In alignment with our research objectives, we formulated the following hypotheses, which will be subjected to empirical testing:

$H_1$: Individuals who positively evaluate the corporate social responsibility (CSR) initiatives of service providers show significantly higher satisfaction with the region's sustainability efforts.

$H_2$: There is a significant relationship between the frequency of information acquisition regarding the social and environmental initiatives of service providers and the willingness to utilize services that lack sustainability commitment.

$H_3$: There are significant differences between the perceived dimensions of service quality and tourists' expectations of the services.

$H_4$: At least one of the examined independent variables significantly influences the level of satisfaction with the services provided in the Danube region.

## THEORETICAL FRAMEWORK

Since the 1980s, the concept of sustainable tourism has focused on balancing the economic, social, and environmental dimensions of tourism. The goal is to meet present needs without compromising the ability of future generations to meet theirs (Hall et al., 2015). Sustainable tourism relies on a well-rounded approach that considers economic, social, and environmental factors, often called the Triple Bottom Line (Happ, 2014; Fleischer, 2014; Correia, 2019). These strategies are crucial not only for minimizing environmental damage but also for supporting local communities. Tourism can, for example, improve social well-being by creating jobs and ensuring that the economic benefits are shared fairly among residents (Ryglová et al., 2011; Hvizdová, 2016; Jarábková et al., 2021). In addition, ethical business practices are becoming more important in the tourism sector (Ásványi, 2022). Environmental sustainability means focusing on things like using less water and energy and cutting down on waste. On the social side, it's about respecting local communities by providing fair working conditions and making sure tourism positively impacts the local economy. Businesses need to think beyond just profits and embrace sustainability in their day-to-day operations. Using recycled materials and adopting eco-friendly practices - especially when encouraged by government incentives - can help in this shift (Ásványi, 2022; Bricker et al., 2013; Gonda, 2022; Pogátsa, 2023). Increasingly, travellers expect businesses to demonstrate a commitment to social responsibility and ethics, making sustainability a key part of tourism marketing (Lőrincz & Sulyok, 2017). Corporate social responsibility (CSR) involves a business strategy where companies consider the social and environmental effects of their operations, in addition to their economic performance (Wirba, 2023). Communicating CSR initiatives effectively is crucial, because consumers are highly sensitive to corporate social responsibility efforts, and positive perceptions can significantly influence purchasing decisions (Mahmud, 2024; Kim & Lee, 2019; Al Jarah & Emeagwali, 2017). When consumers have a favourable view of a company's CSR (Corporate Social Responsibility) efforts, they're more likely to stay loyal and have positive perceptions of the company's products (Bello et al., 2020). However, for CSR to truly work, it's essential that stakeholders are well-informed and that the initiatives are executed effectively (Du et al., 2010). In tourism, understanding service quality and meeting customer expectations is critical. Quality isn't just a fixed measure – it's often subjective, shaped by how individual consumers perceive it (Mohammed Alnasser, Mohammed Alkhozaim, 2024). The

definition of quality can vary widely across different studies. Csizmadia (2023) emphasizes that quality involves making sure something is suitable and has as few flaws as possible. On the other hand, Keller and Kotler (2016) argue that quality is mainly about meeting the needs of customers. In the end, how people judge the quality of a service comes down to their own experiences and perceptions, so individual viewpoints play a crucial role in how services are evaluated (Wirtz and Lovelock, 2016). According to the SERVQUAL model, service quality is also a key determinant of tourist satisfaction (Keller & Kotler, 2016). The significance of service quality is also evident in marketing, as dissatisfied customers can lead to significant competitive disadvantages (Kenesei and Cserdi, 2018; Bilan et al., 2023). The SERVQUAL model's five dimensions – reliability, responsiveness, assurance, empathy, and tangibles – provide an opportunity to systematically identify discrepancies between customer expectations and actual service performance (Heidrich, 2017; Park and Jeong, 2019). However, recent critiques suggest that its five dimensions may not fully capture the experiential and emotional aspects that define tourism (Bauer et al., 2016). Customers often assess service quality based on the gap between perceived and expected services, which subsequently influences their satisfaction (Rane et al., 2023).

Service provider communication plays a crucial role in shaping customer expectations. The failure to fulfil promises has a significant impact on satisfaction and negatively affects the perception of service quality (Kenesei and Kolos, 2014; Bauer et al., 2016; Xie et al., 2024). Kenesei and Kolos (2014) highlight that service providers sometimes lack sufficient information regarding customer expectations or fail to establish adequate quality standards. Customer priorities can vary based on demographic characteristics and the chosen destination (Slabbert, 2011; Otoo et al., 2016).

The optimal level of quality is achieved when customer needs are met at a reasonable cost (Blecharz, 2015). Identifying and analysing such discrepancies is fundamental to the competitiveness of tourism service providers in the region, as customer satisfaction largely depends on service provider performance (Keller and Kotler, 2016; Zeithaml et al., 2017). Applying the SERVQUAL model offers a structured way to evaluate service quality and better understand what customers expect. The insights gathered from this approach allow service providers to address customer priorities more effectively, helping to close the gap between the service customers perceive and what they expect (Wirtz and Lovelock, 2016; Osman and Sentosa, 2013).

Service quality plays a critical role in the competitiveness of businesses, particularly in tourism, where consumer expectations extend far beyond average service levels, making quality a strategic priority (Abduazizov et al., 2023; Heidrich, 2017). Consumer expectations are influenced by various factors, such as past experiences, word-of-mouth recommendations, and service provider

communication (Keller and Kotler, 2016; Kajzar and Mura, 2023). Kenesei and Kolos (2014) emphasize that communication – whether explicit or implicit – defines expectations, thereby influencing satisfaction. Meeting or exceeding these expectations is crucial for customer satisfaction, while unmet expectations can lead to disappointment (Kenesei and Kolos, 2014; Rane et al., 2023).

Tourist satisfaction is closely linked to the discrepancy between expectations and actual experiences, and positive feedback contributes to the sustainability and competitiveness of a region (Maghsoodi et al., 2017; Lőrincz and Sulyok, 2017; Khan et al., 2022). Positive disconfirmation, where service exceeds expectations, enhances satisfaction, while negative disconfirmation diminishes it (Xie, 2022; Li et al., 2020; Wang et al., 2020; Wang and Zhou, 2022). According to Wantara and Prasetyo (2023), effective marketing communication increases tourist satisfaction and their willingness to revisit, a finding also supported by Otto et al. (2020). AlSokkar (2024) points out that fostering expectations and trust is crucial for building satisfaction, while Juliana et al. (2024) emphasize that the multidimensional nature of tourism experiences – sensory, emotional, and social factors – plays a significant role in tourists' intention to return.

Nguyen (2024) finds that reliability, responsiveness, content, accessibility, expectations, and satisfaction are essential factors in consumer decision-making, as these directly influence customer purchasing decisions. Moreover, research by Goo et al. (2022) reveals that new experiences, particularly those driven by novelty-seeking motivations, have a substantial impact on tourist satisfaction, and are not necessarily related to the fulfilment of prior expectations. Tourists seeking novelty often value new and unexpected experiences more than the extent to which their previous expectations are met. Furthermore, Jiang et al. (2022) suggest that certain factors, such as prior travel experiences or concerns related to the destination, strongly influence the relationship between expectations and satisfaction. Tourists who frequently visit a particular location are less likely to perceive travel risks, which may reduce the importance of expectations in determining satisfaction.

The issue of sustainability is increasingly coming to the forefront in rural tourism. Gonda and Rátz (2023) suggest that while tourists are becoming more aware of sustainability issues and consider them important, this is not always reflected in their behaviour in practice. Achieving sustainable development is closely linked to people's environmental awareness and education, which influences their actions and behaviours (Šimková et al., 2024; Matijová et al., 2023; Puciato et al., 2023; Pimonenko, et al., 2021). Commitment to environmental protection and sustainability also plays a significant role in shaping satisfaction, as guests often respond positively to responsible and eco-friendly practices (Khan et al., 2022).

Although age may impact satisfaction, McKercher's (2023) findings indicate that this influence is more related to age and cohort effects rather than fundamental value differences between generations. The travel decisions of Baby Boomers are

largely influenced by hedonistic values and attitudes, while Generations X and Y tend to prefer functional values (Gardiner et al., 2014). Hapsari et al. (2017) argue that the customer service provided by a company and the price charged are highly influential factors in determining customer satisfaction.

The immediate experiences during travel are closely connected to the overall evaluation of the trip, which can be measured based on feelings of satisfaction or dissatisfaction (Zátori, 2018). When customers spend less money, time, and effort relative to the quality of the service received, they perceive the service as high-value (Howat and Assaker, 2013; Hapsari et al., 2016; Yu et al., 2014). Mokhlis (2012) supported the hypothesis that an individual's gender influences perceptions of service quality, and the importance attributed to different service quality dimensions. The study further revealed that tangibles, reliability, and responsiveness are key dimensions of service quality that determine the satisfaction of both male and female customers (Godany and Mura, 2021).

## DATA AND METHODS

The study examined the development opportunities for rural tourism in the Danube region, highlighting the critical factors that ensure tourism services meet or exceed visitor expectations. Through a tourism survey and analysis of the perception of sustainability measures and corporate social responsibility (CSR), the research sheds light on the significant impact of these factors on tourist satisfaction.

The research employed a quantitative methodological approach, utilizing questionnaire-based data collection. The online questionnaire was shared via the Google Forms platform to ensure easy accessibility and support sustainability principles by minimizing the use of paper-based materials. The questionnaire was available in both Hungarian and Slovak, thereby allowing for broader access to tourists. During data collection, a snowball sampling technique was used, initially inviting 100 participants to complete the questionnaire, who were then asked to involve three additional acquaintances with relevant experiences in the region. This non-probabilistic sampling approach allowed us to gather a total of 255 valid responses over a month, sufficient for statistical analysis and drawing reliable conclusions. The recruitment process specifically focused on the existing experiences of tourists visiting the Danube region.

The study paid special attention to ensuring diversity among respondents during the sampling process, thus examining a wide spectrum of tourist experiences. Respondents with varying demographic characteristics, such as different age groups and socio-economic backgrounds, were included in the research. Additionally, the previous experiences of respondents were considered to represent the perspectives of both local residents and tourists. Participation was entirely voluntary and

anonymous, in line with the ethical standards applied in social science research, ensuring the authenticity and honesty of the responses received.

In developing the questionnaire, we focused on ensuring both participants' willingness to engage and their capacity to provide meaningful responses. The questionnaire incorporated various question types, including closed-ended, open-ended, and Likert scale questions, allowing for a detailed assessment of opinions on services. For data analysis, a dual approach was applied: Microsoft Excel was used for data organization and graphical representation, while SPSS statistical software was employed for in-depth hypothesis testing and statistical analysis. This complex analytical framework enabled a thorough exploration of relationships between variables and the drawing of well-founded conclusions regarding tourism satisfaction.

The findings of the study allow rural tourism service providers to enhance their competitiveness, promote sustainable practices, and contribute to environmental protection. The research provides valuable guidance for stakeholders to improve service quality and develop evidence-based strategies for sustainable rural tourism.

## RESULTS AND DISCUSSION

In recent years, the expectation for sustainability has significantly increased among consumers, particularly in tourism, where tourists consider not only the quality of services provided but also their social and environmental impacts. As sustainable tourism and corporate social responsibility (CSR) play an increasingly central role in tourism competitiveness, it was essential to understand the effects of these two factors on tourist satisfaction. The study initially explored whether the Danube region is perceived as effectively addressing sustainability and if the social and economic initiatives of service providers positively impact consumer satisfaction ($H_1$). Survey results show that 71.4% of respondents view current sustainability efforts as moderately effective, though they pointed out areas that require improvement. This finding underscores the rising public awareness of environmental issues and the increasing demand for sustainable practices. It also aligns with the sustainable tourism framework, which posits that consumer satisfaction is heavily influenced by their understanding of sustainability efforts (Hall et al., 2015). The respondents' call for enhanced sustainability efforts is consistent with the increasing expectations for environmentally conscious tourism experiences. An even higher proportion, 85.5%, believe that the social and economic initiatives of service providers positively influence their satisfaction. Among those dissatisfied with the social and economic initiatives of service providers – such as charity projects, community support, and environmental measures – 35.1% believe that the region does not place enough emphasis on sustainability, while 45.9% think there is still room for improvement. Conversely,

18.9% are satisfied with the sustainability measures in the region, despite not perceiving the initiatives as significant from a social perspective. Those who positively evaluate the social and economic initiatives also largely believe that the region adequately emphasizes sustainability (77.2%), with 90.7% acknowledging that, although there is room for further improvement, sustainability measures are fundamentally positive. A Chi-Square test was conducted to examine the relationship between the two categorical variables (Table 1). The condition that no more than 20% of the cells should have an expected value of less than 5 (Csallner, 2015) was indeed met, as only 16.7% of the cells had an expected count below 5, fulfilling the requirement (16.7% < 20%). The Pearson Chi-square test result ($\chi^2 = 18.112$) indicated a significant relationship between the two variables ($p < 0.001$), significantly lower than the conventionally accepted significance level of 1% (0.01). The Cramer's V value (0.267) also confirmed a moderate relationship, thus supporting our hypothesis. The research findings clearly indicate a strong relationship between individuals' views on sustainability and their perception of the social-economic initiatives of service providers. Respondents who positively evaluate CSR are generally more satisfied with the region's sustainability efforts, while less supportive respondents are more likely to demand changes. This trend may result from heightened environmental awareness, evolving social expectations, and a stronger sense of personal responsibility among consumers. Consumers today consider not only the quality of services but also the social and environmental responsibility of companies. Satisfaction largely depends on how authentic visitors perceive CSR efforts, as these reinforce trust in responsible corporate behaviour. When a company genuinely conveys its sustainability initiatives, including environmental efforts and CSR projects, it positively impacts consumer satisfaction by aligning the service provider's actions with the values of its customers. Tourists are placing greater importance on socially and environmentally responsible services, and meeting these expectations leads to increased satisfaction.

**Tab. 1** Examining the Relationship Between Satisfaction with Sustainability Measures in the Danube Region and Support for Service Providers' Socio-Economic Initiatives

| | Value | df | Asymptotic Significance (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 18,112[a] | 2 | <0,001 |
| Likelihood Ratio | 15,089 | 2 | <0,001 |
| Linear-by-Linear Association | 0,000 | 1 | 0,986 |
| Cramer's V | 0,267 | | <0,001 |
| N of Valid Cases | 255 | | |

a. 0 cells (16,7%) have expected count less than 5.

*Source: based on primary data collection, created using SPSS software*

Garay and Font (2012) identified that the most common environmental practices adopted by businesses are waste recycling (88%) and energy and water conservation (77%). In addition, a significant number of companies also implement measures for environmental accountability, use alternative energy sources, offer eco-friendly products, and run environmental promotional campaigns aimed at clients. Consumer assessments of these sustainability measures show mixed results: nearly 70% believe customers occasionally appreciate these initiatives, 22% feel consumers respond positively, and only 8% expect a negative response. This indicates that the majority of businesses receive either positive or moderately positive feedback on their sustainability efforts, which motivates them to continue with environmentally friendly and socially responsible actions.

Wekesa (2024) confirms that consumers are placing greater value on companies that genuinely and transparently communicate their CSR activities, which in turn enhances consumer perception. However, when consumers perceive CSR initiatives as merely marketing tools, skepticism and mistrust can arise (Etikan, 2024; Ko et al., 2023). Although consumer awareness is increasing (Bello et al., 2020), many people remain skeptical of companies' environmental claims unless they are backed by real, tangible actions (Torelli et al., 2020). Sumarmi et al. (2021) point to the effectiveness of community-based ecotourism (CBT) models in fostering sustainable tourism. Strategies such as implementing reservation systems, setting visitor limits, and enforcing strict waste management policies have proven successful in protecting the environment. Additionally, the active participation of local communities, coupled with strategic partnerships, has significantly enhanced conservation efforts and boosted the economic well-being of local populations.

The analysis revealed the relationship between consumers' information-seeking habits and their engagement with services that lacking sustainability commitments. During the analysis, two non-metric variables were examined: the first measured the frequency with which consumers sought information about the social and environmental initiatives of service providers, while the second measured consumers' willingness to support companies that do not prioritize sustainability and environmental protection ($H_2$). Since these variables are non-metric and could not be measured on a continuous scale, Spearman's rank correlation coefficient was employed to analyse the rankings and trends. This method is appropriate for ordinal variables as it is robust against outliers and does not require normally distributed data (Veres et al., 2017). The coefficient was 0.187 (Table 2), indicating a relatively weak yet positive correlation. The p-value was 0.003, which is significant at the 0.01 level, confirming the hypothesis that there is a statistically significant relationship between the two variables. This suggests that consumers who actively seek information about service providers' social and environmental initiatives, demonstrate a greater likelihood of rejecting services that do not exhibit a clear commitment to sustainability. These findings align

with the research of Lin and Huang (2012), which suggests that environmentally conscious consumers tend to engage in more selective decision-making based on the availability of sustainability-related information. Moreover, Testa et al. (2015) highlight the important role of consumer education and awareness in encouraging sustainable consumption. They stress that service providers must improve transparency in their sustainability communications to attract the growing number of eco-conscious consumers. This phenomenon is driven by the role of information-seeking in increasing consumers' environmental awareness and social responsibility. Consumers who actively seek information about companies' sustainability efforts tend to be more critical of businesses that do not meet their expectations. This behaviour reinforces their value system, where sustainability is prioritized, leading them to favour companies that align with these principles. The findings highlight the crucial role of marketing communication and sustainability initiatives in consumer decision-making. Companies that fail to communicate their sustainability efforts transparently risk losing customers, as ethical and environmental factors increasingly shape consumer preferences. Therefore, information-seeking is a key factor influencing consumer choices, particularly when a company's commitment to sustainability is unclear.

**Tab. 2** Correlation Between Frequency of Information-Seeking on Service Providers' Social and Environmental Initiatives and Willingness to Use Services Without Sustainability Commitment

| | | | Frequency of Information-Seeking on Providers' Social and Environmental Initiatives | Willingness to Use Services Without Commitment |
|---|---|---|---|---|
| **Spearman's rho** | Frequency of Information-Seeking on Providers' Social and Environmental Initiatives | **Correlation Coefficient** | 1,000 | 0,187** |
| | | **Sig. (2-tailed)** | . | 0,003 |
| | | **N** | 255 | 255 |
| | Willingness to Use Services Without Commitment | **Correlation Coefficient** | 0,187** | 1,000 |
| | | **Sig. (2-tailed)** | 0,003 | . |
| | | **N** | 255 | 255 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Source: based on primary data collection, created using SPSS software*

Our findings indicate that consumers actively seek information about companies' social and environmental impacts. The significant correlation coefficient suggests that whilst sustainability considerations are not paramount

for all consumers, they increasingly influence the decision-making processes that determine service utilisation. Testa et al. (2015) posit that a lack of information can hinder environmentally friendly behaviour. Kemp et al. (2012) highlighted that information can elicit strong emotions, which immediately affect consumers. Lin and Huang (2012) established that environmental concerns influence consumption values and choice decisions.

For our next hypothesis ($H_3$), a comparative analysis was conducted between the dimensions of service quality and the expectations set for services. The results were analysed using the Wilcoxon signed-rank test (Table 3), which allows for the statistical examination of ranked differences between paired samples. The application of the Wilcoxon test was justified given the non-parametric nature of the data, which is typical for responses measured on a Likert scale (Saha – Paul, 2023). The results indicated significant discrepancies between the perceived service quality attributes and their importance ratings. For example, there was a particularly large difference between perception and expectation in the "Safe and Clean Environment" dimension ($Z = -7.935$, $p < 0.001$). Similarly, significant differences were also found in "Responsiveness" and "Reliable and Timely Service Delivery." In the "Understanding Individual Needs" dimension, significant differences were observed as well, although these were less pronounced compared to other dimensions. The analysis at a 99% significance level ensured a high degree of reliability for the results, minimising the risk of false positive conclusions (Field, 2017). Our findings support the alternative hypothesis that there are substantial differences between the perceived quality of services and their importance expectations. This discrepancy can be attributed to several factors. One primary reason is the differing priorities between service providers and consumers. While providers focus on efficiency and cost optimization, consumers often prioritize experience-driven aspects like safety and cleanliness. Communication challenges also contribute to this gap, as consumer dissatisfaction frequently arises from inadequate information about the efforts of service providers or unclear communication of expectations. The RURALQUAL model, which is employed in studies of rural tourism, highlights the significant correlation between service quality and consumer satisfaction, emphasizing that communication failures can harm trust and loyalty (Marković & Kljaić Šebrek, 2020). Additionally, technological advancements can widen the gap between expectations and services, as consumers quickly adopt new trends that service providers may struggle to meet. The RURALQUAL model also found that safety, customer relations, and integration with the rural environment are key dimensions of service quality (Marković & Kljaić Šebrek, 2020). However, service providers often focus more on technical elements, while neglecting "soft" aspects like communication and responsiveness, which are equally important for enhancing the consumer experience. Service quality in the tourism sector can also be analysed through the Gap Model, which identifies

specific discrepancies between expected and actual services (Bauer et al., 2016; Wirtz & Lovelock, 2016). One such gap is the knowledge gap, where providers fail to fully understand consumer needs due to insufficient research or managerial involvement. Another is the standards gap, which occurs when clear service performance benchmarks are not established, and the performance gap, where employees lack adequate training to meet these benchmarks. Additionally, the communication gap arises when marketing promises exceed the service's actual capabilities, and the perception gap reflects the disconnect between the service delivered and how customers perceive it. To bridge these gaps, tourism providers need to gain a better understanding of customer expectations and communicate more effectively about the steps they are taking to improve service quality.

**Tab. 3** Examination of the Disparity Between Perceived Service Quality and Its Importance Expectations Using the Wilcoxon Signed-Rank Test

| | Perception and Importance Rating of **Safe and Clean Environment** | Perception and Importance Rating of **Responsiveness** | Perception and Importance Rating of **Courteous and Helpful Staff** | Perception and Importance Rating of **Service Provider Accessibility and Availability** | Perception and Importance Rating of **Reliable and Timely Service Delivery** | Perception and Importance Rating of **Understanding Individual Needs.** |
|---|---|---|---|---|---|---|
| **Z** | -7,935[b] | -5,371[b] | -7,607[b] | -5,970[b] | -7,309[b] | -4,301[b] |
| **Asymp. Sig. (2-tailed)** | 0,001 | 0,001 | 0,001 | 0,001 | 0,001 | 0,001 |

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks

*Source: based on primary data collection, created using SPSS software*

The findings reveal significant discrepancies between the service quality that suppliers provided by and the level expected by tourists. Service providers may not fully recognise or adequately meet their clients' priorities (Bauer et al., 2016; Keller & Kotter, 2016; Kenesei & Cserdi, 2018; Wirtz & Lovelock, 2016). This disparity poses a considerable challenge for the industry. According to Jocić et al. (2024), tourism functions as an 'experience factory' where each element of the value chain must be of high quality to ensure exceptionally positive tourist experiences. Grazhdani and Merollari (2015) demonstrated that demographic factors influence customer expectations, suggesting that segmentation can effectively enhance satisfaction. Ladhari (2020) concluded that reliability and responsiveness are fundamental factors that significantly impact customer loyalty. Brady and Cronin (2001) found

that while perceptions of service quality may vary across industries, reliability remains consistently important across all sectors. Customers view service quality as a general expectation rather than an added value for which they would pay extra.

Numerous studies indicate that appropriate pricing is crucial for customer satisfaction, as fair pricing contributes to contentment (Cardia et al., 2019; Cai et al., 2021; Zhao et al., 2021; Safitri et al., 2023; Prasilowati et al., 2021). Excessively high prices not aligned with the value provided, or a lack of discounts, may diminish customer satisfaction. However, low prices do not automatically guarantee increased satisfaction if the quality of service is unsatisfactory (Subaebasni et al., 2019).

A comprehensive literature review and the results of preliminary research have demonstrated that consumer satisfaction is a complex, multidimensional phenomenon influenced by numerous factors. The purpose of the present regression analysis (Table 4) was to identify the determinants of customer satisfaction related to services in the Danube region ($H_4$). The analysis revealed that factors influencing expectations, including the service provider's image, ratings, reviews, recommendations, previous experiences, and advertisements, have a significantly positive effect on customer satisfaction ($B = 0.291$, $p < 0.001$). This result suggests that customer expectations play a crucial role in shaping satisfaction, as they directly influence perceptions of the service. Expectations determine how the quality of services is assessed, and the level of customer satisfaction largely depends on how well the service meets these expectations. General satisfaction with facilities ($B = 0.508$, $p < 0.001$) also showed a significant and positive effect, indicating that the quality of facilities directly contributes to the consumer experience. The tangible experiences provided by the facilities enhance satisfaction, as high-quality infrastructure and environment positively influence perceptions of the service. In contrast, the price-value ratio did not show a significant relationship with customer satisfaction ($B = -0.023$, $p = 0.504$), suggesting that in this region, consumers do not primarily evaluate services based on price. This may be explained by the unique characteristics of the tourism in the Danube region, where experience and service quality are of primary importance to customers, who are less price-sensitive. This is particularly true in areas where cultural and historical attractions enhance the travel experience, and thus satisfaction is more influenced by the quality of the experience than by the price-value ratio. The analysis of gender differences did not reveal a significant impact on customer satisfaction ($B = 0.029$, $p = 0.755$), suggesting that the satisfaction levels of men and women do not statistically differ. This result indicates that service providers are equally capable of meeting the needs of both genders, and therefore, gender is not a determining factor in predicting customer satisfaction. However, significant differences were observed between different age groups, with the satisfaction level of those aged 41-57 being significantly higher compared to the reference

group of 27-40 years (B = 0.266, p = 0.012). This suggest9827s that this age group, typically with more stable financial circumstances and greater travel experience, has more realistic expectations of services, making them more likely to be satisfied. No significant differences in satisfaction were found for the under-26 and over-58 age groups, suggesting that despite differing needs, the services in the region are able to meet expectations consistently across these age brackets. In summary, the regression analysis identified three key factors that significantly influence customer satisfaction: factors shaping expectations, the quality of facilities, and certain age groups. These results suggest that the formation of customer satisfaction is primarily linked to the quality of service and alignment with expectations, while the price-value ratio and gender do not play a decisive role.

**Tab. 4** Impact of Individual Predictors in the Linear Regression Model on Satisfaction with Service Quality

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | | | Tolerance | VIF |
| **Factors influencing expectations** | 0,291 | 0,055 | 0,282 | 5,314 | 0,001 | 0,908 | 1,102 |
| **General satisfaction with service provider Facilities** | 0,508 | 0,060 | 0,447 | 8,421 | 0,001 | 0,904 | 1,106 |
| **Perception of price-value ratio** | -0,023 | 0,035 | -0,035 | -0,670 | 0,504 | 0,946 | 1,058 |
| **Male** | 0,029 | 0,094 | 0,016 | 0,313 | 0,755 | 0,926 | 1,080 |
| **Under 26 years old** | 0,191 | 0,107 | 0,109 | 1,793 | 0,074 | 0,688 | 1,453 |
| **Aged 41 – 57** | 0,266 | 0,105 | 0,153 | 2,527 | 0,012 | 0,694 | 1,440 |
| **Over 58 years old** | 0,242 | 0,134 | 0,101 | 1,805 | 0,072 | 0,813 | 1,230 |

a. Dependent Variable: Level of satisfaction with the quality of service provided in the region

*Source: based on primary data collection, created using SPSS software*

In the final section of our survey, we asked respondents if they had experienced any unique services or activities in the region that made their stay memorable. Our analysis focused on two main factors: the residency status of respondents (locals vs. visitors) and whether they encountered any exceptional experiences. Interestingly, a much higher percentage of non-locals (86.49%) felt that the region lacked unique experiences compared to locals (76.24%). On the other hand, more locals (23.76%)

reported finding distinctive aspects of the region, while only 13.51% of visitors had the same experience. This difference could be explained by the fact that locals are more exposed to special events and opportunities, whereas visitors, due to their shorter stays, may miss out on these experiences. Alternatively, it's possible that locals, having grown accustomed to the region, may find its unique aspects less remarkable.

The findings indicate that the region may require considerable enhancements to increase its distinctiveness. Among the memorable experiences mentioned, hospitality stood out. Respondents highlighted the high-quality dining options, praising not only the food but also the attention to food allergies and the personalized service provided. Many valued the extra effort establishments put into catering to dietary restrictions with professionalism and care. Culturally, a range of artistic and historical activities—such as festivals, concerts, and guided tours—were also well-received. Additionally, small gestures, like unexpected gifts or personalized amenities at hotels, made stays even more memorable. Families especially appreciated the availability of child-friendly environments. When asked about areas for improvement, 39.22% of respondents placed the highest priority on creating new and attractive tourism events. Service quality was another significant concern, emphasized by 29.80% of participants. Other suggestions included enhancing and streamlining the region's information system (12.16%), promoting environmental sustainability initiatives (8.63%), and increasing staff training to elevate service standards (7.45%).

Open-ended feedback provided additional insights. Respondents expressed a desire for better recreational facilities, like more refreshment spots along bike paths, including cafés, ice cream stands, and food stalls. Many criticized the lack of customer-focused services, citing issues such as unhelpful staff and impersonal communication, especially in restaurants. There were also concerns about professionalism, with participants calling for clearer and more courteous communication from service providers. Environmental education was another priority, with respondents stressing the importance of teaching ecological awareness to children to help foster a stronger connection with the region and encourage them to stay. Lastly, improving economic conditions and raising wages were highlighted as ways to reduce emigration, which could, in turn, boost school enrollments and support regional sustainability.

Like many research endeavours, this study on rural tourism in the Danube region, whilst providing valuable insights, is subject to certain limitations. These constraints, however, offer opportunities for future research and refinement of methodologies. The non-probabilistic snowball sampling technique, although yielding 255 valid responses, may limit generalisability of the findings. Additionally, the study's focus on a single region and the questionnaire's availability only in Hungarian and Slovak potentially restrict its applicability and demographic reach.

The use of online questionnaires via Google Forms, chosen for sustainability reasons, might have inadvertently excluded certain groups, such as those with limited internet access. To address these limitations, future studies could enhance the robustness of conclusions by incorporating probabilistic sampling methods and expanding the geographical scope to facilitate comparative analyses across regions. Including additional languages and integrating qualitative methods, such as interviews or focus groups, would provide deeper, more nuanced insights by capturing the perspectives of diverse stakeholders. Additionally, future research should conduct subgroup analyses and examine interaction effects to deeply understand how variables such as demographics, cultural background, and travel motivations influence consumer satisfaction in rural tourism. Furthermore, a deeper exploration of the link between CSR and service quality is needed to provide a more thorough understanding of their combined impact on consumer perceptions.

## CONCLUSIONS

The research highlights the significant impact of social and environmental responsibility initiatives on tourists' perceptions, validating theoretical models of corporate social responsibility (CSR) and sustainable tourism (Ásványi, 2022; Hall et al., 2015; Mahmud, 2024; Bello et al., 2020). Our findings contribute to the growing literature by demonstrating that businesses adopting sustainability principles not only meet consumer expectations but also enhance overall satisfaction. The strategic importance of CSR and sustainability is evident, as tourists' express satisfaction while consistently seeking improvements in these areas. However, the literature reveals that the relationship between CSR initiatives and customer satisfaction is not always positive. Several studies have found that the influence of CSR on customer perceptions is contingent on factors such as consumer awareness, the perceived authenticity of CSR efforts, and the alignment between CSR activities and the core business operations of the company (Kim & Lee, 2019; Ko et al., 2023). For instance, Kim and Lee (2019) found that when a company's CSR initiatives closely align with its main business activities – a concept known as high CSR fit – consumers perceive these efforts as more authentic, which positively influences their attitude toward the brand. However, they also discovered that consumers who are highly engaged in CSR are less influenced by CSR fit when assessing authenticity. For these consumers, the genuineness of CSR efforts does not heavily depend on how closely the CSR activities are related to the company's core business. CSR initiatives can influence customer satisfaction in both positive and negative ways, depending on the type of activities and how they are communicated (Du et al., 2010; Rivera et al. 2016; Kim & Lee, 2019; Garay & Font, 2012; Hapsari et al., 2017). Therefore, developing a unified sustainability criterion and certification system for tourism service providers is warranted. Such a system

should evaluate not only the quality of services but also their environmental and social impacts, enabling consumers to make more informed decisions and fostering greater trust in businesses demonstrating a clear commitment. However, the findings in the literature regarding the impact of CSR on customer satisfaction indicate that merely implementing CSR initiatives is not sufficient. The study indicates that sustainability and social responsibility require a comprehensive approach, as consumers perceive these concepts as closely interconnected.

The results support the alternative hypothesis that a significant positive relationship exists between the frequency of consumers' information-seeking and their willingness to reject services lacking a commitment to sustainability. This finding suggests that informed consumers are more inclined to choose service providers who adhere to sustainable practices, indirectly encouraging companies to adopt and develop these initiatives. This is particularly important given the significant discrepancies identified by the Wilcoxon signed-rank test between the perception of service quality attributes and their importance ratings. Such discrepancies indicate that service providers may not always fully meet customer expectations, underscoring the need to explore development opportunities and establish customer-centric solutions. To bridge the gaps between service quality and customer expectations, it is advisable to implement comprehensive quality improvement programs that incorporate sustainability and CSR at their core. These programs should include efficient consumer feedback mechanisms, enabling providers to respond promptly to customer input and adapt swiftly to evolving needs. Integrating complaint-handling processes into broader service development strategies can provide significant benefits, particularly in managing expectations and continuously enhancing service quality. By aligning sustainable efforts with service quality strategies, providers can better meet consumer expectations, which increasingly emphasize high-quality experiences underpinned by ethical and sustainable practices.

Our findings challenge conventional assumptions about the importance of price in customer satisfaction. In the Danube region, for instance, service quality and experiential value are consistently prioritized over price. However, findings from other regions indicate that price sensitivity can vary depending on demographic and cultural factors (Fu et al., 2020; Subaebasni et al., 2019; Ronnie & Philip, 2021; Matlovič & Matlovičová, 2024). Additionally, the lack of significant differences in satisfaction levels between genders implies that service providers are effectively meeting the needs of both male and female tourists equally. Based on the research, it is recommended to develop age-specific marketing and service strategies. Addressing the differing preferences of younger generations is also essential to cater to a broader customer base. Studies have shown that generational differences can significantly impact travel behaviour and expectations, necessitating tailored approaches (Gardiner et al., 2014; McKercher, 2023).

This study highlights a critical need for the region to develop its unique offerings to better attract tourists, as 86.49% of non-residents did not perceive any distinctive experiences during their stay. This lack of engagement with the region's unique characteristics emphasizes the importance of targeted strategies to enhance its identity and promote its distinctive features. Respondents identified memorable experiences, particularly in the areas of gastronomy and personalised service. Exceptional culinary offerings, along with attentive service that accommodates dietary preferences, were highly valued. Establishments providing professional, personalised services significantly enhanced visitor satisfaction. Creating family-friendly environments has also been a key factor in increasing visitor satisfaction, particularly for those with children. The study suggests that the region should focus on developing new and engaging tourism events, such as cultural festivals, food fairs, and historical re-enactments, which highlight local traditions and appeal to both residents and visitors. Collaborating with local artists and institutions to expand cultural programming can attract a broader audience and deepen cultural engagement. Additionally, cultural programmes like festivals, theatre performances, concerts, and guided historical tours fostered a deeper connection with the region's heritage.

Adding value to accommodation services, through personalised amenities like welcome, also leaves a lasting positive impression. A focus on family-friendly services further enhances guest satisfaction. Improving service quality is another priority, and this can be achieved through comprehensive staff training. Focusing on customer service, communication, and cultural sensitivity will enable staff to meet visitor expectations more effectively. Optimising information systems is crucial for enhancing accessibility. Developing a centralised website and mobile application with updated event and service information, alongside leveraging social media for outreach, can significantly increase visitor engagement.

Achieving these objectives will require collaboration among local authorities, businesses, and the community. By focusing on personalised hospitality, rich cultural experiences, and sustainability, the region can meet current tourism demands while securing long-term success and enhancing its reputation as a desirable destination.

Table 5 presents the results of the hypothesis testing, confirming the acceptance of all alternative hypotheses.

**Tab 5.** Summary of hypothesis testing results

| | | Test applied | Outcome | Decision |
|---|---|---|---|---|
| $H_1$ | Positive evaluations of CSR initiatives correlate with higher satisfaction with the region's sustainability efforts. | Pearson Chi-square test | $p < 0.001$ | The alternative hypothesis is accepted at the 1% significance level. |
| $H_2$ | Information-seeking about social and environmental initiatives is significantly related to the willingness to use unsustainable services. | Spearman's rank correlation | $p < 0.003$ | The alternative hypothesis is accepted at the 1% significance level. |
| $H_3$ | Significant differences exist between perceived service quality and tourists' expectations. | Wilcoxon signed-rank test | $p < 0.001$ | The alternative hypothesis is accepted at the 1% significance level. |
| $H_4$ | At least one independent variable significantly impacts satisfaction with services in the Danube region. | Linear Regression Model | The significance of individual variables is presented in Table 4. | Due to the identification of multiple variables, the alternative hypothesis has been accepted |

*Source: based on primary data collection*

While this study offers valuable insights, it is important to acknowledge its limitations. The use of a non-probabilistic sampling method and the focus on a single region may affect the generalisability of the findings. Future research should address these limitations to enhance the robustness of the conclusions and provide a more comprehensive understanding of consumer satisfaction in rural tourism.

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# A SPATIAL ANALYSIS OF DEMOGRAPHIC AND CURRICULAR INFLUENCES ON SECONDARY EDUCATION IN SLOVAKIA

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**Abstract**
Regional disparities in secondary education present significant obstacles to equitable human capital development, particularly in areas where demographic decline and resource imbalances exacerbate the issue. This study examines the spatial and structural dynamics of secondary education enrollment in Slovakia, focusing on demographic and curricular factors. Using a random-effects spatial error model, we analyze panel data from districts over two decades (2003-2023). The model accounts for spatial interdependencies while addressing unobservable district-level heterogeneity. Specification tests confirm the model's validity, demonstrating strong spatial autocorrelation in outcomes but minimal residual dependencies. The results indicate that secondary school enrollment clusters around urban districts, which consistently outperform rural areas. Youth and population density are the strongest predictors of enrollment, while curricular specialization also plays a critical role. Technical and medical programs positively impact enrollment, whereas agricultural and artistic programs show weaker effects. Interestingly, a higher proportion of university-educated residents correlates negatively with secondary enrollment, likely reflecting talent migration from rural districts. The results highlight the geographical clustering of high-performing districts in proximity to urban areas, influenced by demographic benefits and educational programs tailored to meet labor market demands. In contrast, remote regions face persistent challenges tied to structural and demographic disadvantages. Addressing these disparities will require strategic investments in digital infrastructure, curriculum modernization, and demographic stabilization policies.

**Key words**
Demographic shifts, education dynamics, equity, human capital, regional disparities, secondary education, spatial econometrics**.**

## INTRODUCTION

In an era of rapid technological progress and shifting demographic trends, education systems play an increasingly pivotal role in driving regional development. Human capital—defined as the skills, knowledge, and capabilities of individuals—has become a base of economic resilience and societal well-being. However, the spatial distribution of educational opportunities remains highly uneven, often mirroring and reinforcing existing socio-economic disparities. These challenges are particularly acute in countries where historical legacies, demographic shifts, and regional inequalities converge to shape the educational landscape. Slovakia's secondary education system operates amid significant demographic pressures, including a declining youth population and migration-driven urbanization. Over the past two decades, the proportion of young people aged 15–19 has declined sharply, with rural areas bearing the burden of these demographic shifts.

This demographic shift exacerbates challenges in peripheral regions, where educational institutions face difficulties maintaining viability and curricular offerings often fail to align with local labor market needs. These trends highlight the importance of understanding the geographic and structural dynamics of secondary education and their implications for regional development. The geographic dimension of education, frequently overlooked in traditional analyses, provides a valuable perspective for addressing these issues. Spatial education dynamics—including the distribution of schools, accessibility of educational opportunities, and the spatial clustering of outcomes—play a critical role in shaping human capital formation. High-performing regions benefit from concentrated resources and institutional networks, while disadvantaged areas are often trapped in cycles of underinvestment and depopulation. Examining the interplay between these spatial factors and human capital theory offers a robust framework for understanding how education systems can mitigate regional disparities and promote equitable development.

This study examines secondary education system within a broader theoretical framework, addressing two central questions. First, how do demographic and spatial factors shape the distribution and accessibility of secondary education across regions? Second, to what extent do curricular offerings align with regional economic needs, and how do specialized programs influence educational outcomes? These questions are particularly relevant as Slovakia continues its transition to a knowledge-based economy, where aligning education with labor market demands is essential for regional competitiveness. To explore these issues, the study employs a spatial econometric approach, using panel data on secondary school enrollment, demographic trends, and economic conditions across Slovakia's districts. A spatial autoregressive model is applied to account for both

local determinants and geographic interdependencies, offering deeper insights into the spatial and structural dynamics of secondary education.

By integrating theoretical insights on human capital and spatial education dynamics with empirical analysis, this research aims to advance both understanding and policy discussions on educational equity and regional development. The paper is structured as follows: the introduction is followed by a theoretical framework that explores the concepts of human capital, spatial education dynamics, and their implications for regional development. The methodological section details the spatial econometric approach employed in the analysis, leading to a results section that identifies key patterns and disparities in Slovakia's secondary education system. The discussion situates these findings within broader theoretical and policy contexts, offering recommendations to promote educational equity and strengthen regional resilience. This study addresses the specific challenges confronting Slovakia and contributes to the broader discourse on how education systems can reduce regional disparities amid demographic and economic transformations.

## THEORETICAL FRAMEWORK

### *Human capital, development, and technological change*

Human capital, encompassing the collective skills, knowledge, and abilities that drive economic productivity, has been a basis of regional development theory. Since its formalization in economic studies, the concept has evolved to include spatial dimensions, its integration with technological change, and its potential to address socio-economic inequalities. Piketty and Saez (2014) highlight the influence of wealth and human capital disparities on regional economic paths and their implications for development policies. More recently, Yang (2023) introduced the concept of human capital space, emphasizing its critical role in fostering dynamic capabilities within cities and regions. The foundational works of Becker (1964) and Schultz (1961) framed human capital as a determinant of both individual and societal economic outcomes, arguing that investments in education and training yield significant returns in productivity, earnings, and growth. Building on this foundation, Lucas (1988) highlighted the externalities of human capital, proposing that an educated workforce enhances individual productivity and generates spillover effects that benefit entire regions.

Contemporary scholarship has expanded and critiqued foundational theories of human capital. Sen (1997) reframed the concept beyond its economic utility, highlighting its role in enhancing individual freedoms and societal well-being. This perspective emphasizes equitable access to education as essential for addressing broader socio-economic inequalities. Recent research has highlighted the importance of the spatial distribution of human capital as a significant factor

contributing to regional disparities (Moretti, 2012). Areas with a higher density of educated individuals are more likely to draw investment, promote innovation, and exhibit enhanced economic resilience. In contrast, regions with low human capital often experience stagnation and depopulation, perpetuating cycles of underdevelopment (Rodríguez-Pose and Tselios, 2011; Strielkowski et al., 2013). Glaeser et al. (2011) argue that cities function as talent magnets, facilitating knowledge exchange and innovation. This dynamic is further reinforced by Florida's (2002) creative class thesis, which proposes that regions attracting skilled and creative workers are more likely to thrive in the knowledge economy. Additionally, Bowles et al. (2001) highlight the importance of non-cognitive skills and personality traits in enhancing the economic returns of human capital, reshaping traditional understandings of education and productivity.

Agglomeration effects, while fostering growth in urban centers, can exacerbate regional inequalities by concentrating resources and opportunities in cities at the expense of rural areas. Peripheral regions often face human capital traps, where limited educational and economic prospects drive young, educated individuals to migrate in search of better opportunities (Bahna, 2013). This phenomenon erodes the socio-economic fabric of these regions and hinders their recovery from economic downturns (Novotný, 2016). Recent studies (Barzotto, 2024) emphasize the need for policy interventions to retain talent in lagging regions, such as improving local education systems and aligning curricula with regional labor market demands. Another line of research explores the spatial mismatch between human capital and labor market demand. Sutton (2017) highlights that regions with an oversupply of educated individuals but insufficient job opportunities face underemployment, diminishing the returns on human capital investments. This issue is particularly acute in Slovakia, where regional disparities in industrial structure and economic activity limit the effective use of local talent. Rodríguez-Pose (2018) contends that areas labeled as "places that don't matter" frequently face economic stagnation and political instability, highlighting the necessity for human capital development strategies that are specifically tailored to these regions.

The advent of Industry 4.0 has fundamentally altered the nature of work and the skills required in the labor market. Automation, digitalization, and artificial intelligence are reshaping industries, increasing demand for high-skilled labor while reducing opportunities for low-skilled workers (Grenčíková et al., 2021; Mocák et al., 2022). This shift has significant implications for regional development, as areas with inadequate educational infrastructure struggle to keep pace with these changes. Technological advancements have led to skill polarization, with high-skilled jobs on the rise and middle-skilled jobs declining (Popjaková and Mintálová, 2019; Nurković, 2020). Kovács and Domonkos (2024) argue that this trend exacerbates regional inequalities, as urban centers are better equipped to

provide advanced training and attract high-skilled industries, leaving rural regions further behind. In response to these challenges, policymakers have stressed the importance of lifelong learning and reskilling programs to prepare workers for the evolving labor market. Rusnák et al. (2024) suggest that aligning the supply of secondary vocational graduates with labor market demands, particularly through an industrial structure of related variety, is essential for addressing skill gaps. Grenčíková et al. (2021) highlight that regions investing in continuous education and training exhibit higher adaptability and economic resilience, making such programs a critical element of regional development strategies. Additionally, Autor and Salomons (2018) provide evidence that while automation displaces certain job segments, it has also contributed to net employment growth in other sectors.

*Demographic transitions and education dynamics*

Demographic trends, such as aging populations and declining birth rates, present significant challenges to the sustainability of human capital. Auerbach and Lee (2010) stress that regions facing population decline must focus on the efficient allocation of educational resources to maximize the potential of a shrinking youth cohort. In Slovakia, the demographic changes have highlighted the necessity for focused initiatives aimed at tackling regional inequalities in both educational access and quality (Szabo and Bleha, 2018). Migration patterns play a crucial role in shaping the spatial distribution of human capital. While urban centers benefit from an influx of young, educated individuals, rural areas often face depopulation and workforce shortages. Bahna (2013) observes that international migration exacerbates these challenges, as highly skilled Slovaks seek opportunities abroad, leaving a gap in the local talent pool. Rees et al. (2016) highlight how internal migration influences regional population distributions, shaping the availability and accessibility of educational resources.

Emerging research also highlights the role of gender in shaping human capital dynamics. Vidyattama et al. (2019) contend that addressing gender disparities in education and labor market participation can unlock untapped potential, fostering regional growth. Klasen and Lamanna (2009) emphasize that reducing gender disparities in education and employment yields substantial positive effects on both economic growth and regional equity. In Slovakia, policies promoting gender equity in education and employment could play a key role in reducing regional disparities. Demographic trends significantly influence the demand for and supply of education. Over the past two decades, Slovakia has seen a decline in its youth population, shifting public policy from expansion to consolidation in the education sector (Auerbach and Lee, 2010). However, this transition has not been uniform across regions, leading to divergent educational outcomes. Theories of educational

equity assert that equal access to quality education is crucial for reducing regional disparities and promoting socio-economic mobility (Brown et al., 2013). Factors such as population density, age distribution, and migration patterns affect the spatial distribution of educational resources (Gibbons and Vignoles, 2012).

The historical legacy of centralized education under socialism has resulted in an uneven distribution of secondary schools, particularly in rural areas. While post-1990s decentralization efforts aimed to address these imbalances, they have not fully mitigated regional inequalities (Haratyak, 2013; Luczaj and Bahna, 2018). The spatial dynamics of education systems include the geographic distribution of institutions, access to quality education, and the outcomes these factors generate. These dynamics are shaped by socio-economic, political, and cultural influences, often reflecting and reinforcing broader regional inequalities (Katrňák et al., 2006; Baláž, 2007). Theoretical progress in the field of spatial education research highlights the significance of geographic location, spatial clustering, and the distinctions between urban and rural areas in influencing educational accessibility and its effects on regional development. Chetty et al. (2014) demonstrate how geographic disparities in intergenerational mobility are linked to differences in educational quality and accessibility, highlighting the critical role of equity in promoting social advancement.

Initial research on population migration, conducted by Ravenstein (1889), highlighted the significance of resource accessibility. This idea was subsequently broadened by social geographers to encompass the role of education, as noted by Gibbons and Vignoles (2012). These early theories illustrate the impact of geographical distance and regional infrastructure on educational success. Proximity to schools plays a crucial role in enrollment rates and educational outcomes, especially in rural areas, where limited infrastructure often requires students to travel long distances. Studies (Novotný, 2015) show a strong correlation between proximity to secondary schools and higher enrollment, particularly among low-income households unable to afford private transportation. Recent research, incorporating network theory, examines the interconnections between institutions, communities, and labor markets. This approach reveals that clusters of schools in urban areas create competitive advantages through resource sharing and collaboration, often disadvantaging isolated rural schools (Sykes and Kuyper, 2013).

**Table 1:** The population variation in the various regions of Slovakia among individuals aged 15-19.

| Region | Year | Population | | Population change (%) | |
|---|---|---|---|---|---|
| | | Total (Th.) | 15-19 (%) | Total | 15-19 |
| Bratislava | 2003 | 599.8 | 7.5 | 2.6 | -44.0 |
| | 2013 | 615.5 | 4.1 | 18.7 | 21.1 |
| | 2023 | 730.6 | 4.2 | - | - |
| Trnava | 2003 | 551.3 | 7.7 | 1.0 | -30.4 |
| | 2013 | 557.1 | 5.3 | 1.6 | -14.0 |
| | 2023 | 565.8 | 4.5 | - | - |
| Trenčín | 2003 | 602.7 | 7.9 | -1.6 | -33.1 |
| | 2013 | 592.8 | 5.4 | -3.9 | -21.4 |
| | 2023 | 569.4 | 4.4 | - | - |
| Nitra | 2003 | 710.1 | 7.6 | -3.2 | -31.6 |
| | 2013 | 687.5 | 5.4 | -2.6 | -18.5 |
| | 2023 | 669.5 | 4.5 | - | - |
| Žilina | 2003 | 693.2 | 8.2 | -0.4 | -24.2 |
| | 2013 | 690.3 | 6.2 | -0.4 | -19.3 |
| | 2023 | 687.6 | 5.1 | - | - |
| Banská Bystrica | 2003 | 659.4 | 7.9 | -0.3 | -28.7 |
| | 2013 | 657.7 | 5.6 | -6.3 | -17.7 |
| | 2023 | 616.1 | 5.0 | - | - |
| Prešov | 2003 | 794.0 | 8.8 | 3.0 | -18.5 |
| | 2013 | 818.1 | 6.9 | -1.2 | -17.8 |
| | 2023 | 808.5 | 5.8 | - | - |
| Košice | 2003 | 768.4 | 8.3 | 3.4 | -22.6 |
| | 2013 | 794.4 | 6.2 | -1.9 | -10.3 |
| | 2023 | 779.3 | 5.7 | - | - |

The data presented includes the total population figures and the percentage of individuals within the 15-19 age group in each region for the years 2003, 2013, and 2023. This information offers insights into the changes in demographics and the patterns of population increase or decrease witnessed in diverse regions.

*Source: Statistical Office of the Slovak Republic (2024a).*

### *Patterns of educational inequality*

Educational inequality is often embedded in spatial patterns, reflecting broader socio-economic disparities. These patterns are shaped by factors such as urbanization, regional economic structures, and the historical legacies of policy decisions (Allmendinger, 1989; Douglass, 2010; Brown et al., 2013). Mouw and Kalleberg (2010) explore the structural shifts in the labor market, linking wage

inequality to the evolving educational demands of occupations. Urban centers tend to offer better access to quality education due to higher population densities and more favorable resource allocation. In contrast, rural areas face challenges like teacher shortages, outdated infrastructure, and limited curricular offerings (Mussida et al., 2019). These disparities are particularly pronounced in post-socialist countries, where the transition to market economies disrupted centralized education systems. Spatial segregation in education occurs when socio-economic factors lead to the concentration of disadvantaged or advantaged populations in specific areas. This clustering perpetuates inequality, as schools in wealthier regions benefit from better funding and parental involvement, while schools in poorer areas struggle with resource deficits (Rodríguez-Pose and Tselios, 2011).

Regions experiencing demographic decline often face the consolidation of schools and reduced curricular diversity, further marginalizing students in these areas. Szabo and Bleha (2018) highlight that rural regions are especially vulnerable, as declining youth populations undermine the viability of local schools. Research shows that high-performing schools tend to cluster in urban or economically prosperous areas, creating hubs of educational excellence (Florida et al., 2008). This clustering is tied to broader socio-economic advantages, such as access to skilled teachers, modern facilities, and extracurricular opportunities. Feedback loops between educational outcomes and regional development intensify these disparities. For example, regions with high-performing schools attract families seeking better education, which increases local tax revenues and further enhances school funding (Glaeser et al., 2011). In contrast, low-performing regions are trapped in cycles of depopulation and underinvestment, perpetuating educational disadvantage. The concentration of institutions in cities enables resource sharing, professional development for teachers, and collaboration with industries (Michaels and Stevick, 2009).

However, rapid urbanization can lead to overcrowded schools, competition for resources, and socio-economic segregation. Studies in Slovakia (Pazúr et al., 2017) show that while Bratislava benefits from urban growth, neighboring regions often face negative spillover effects, such as rising housing costs that limit access to urban schools. Effective policy interventions are crucial for addressing spatial disparities in education. International case studies offer valuable lessons in tackling these challenges. While decentralization enables greater local control, it can exacerbate regional inequalities if resources are distributed unevenly. The shift to decentralized education governance has benefited urban centers but left rural areas at a disadvantage. Balancing local autonomy with centralized support is essential for achieving equitable outcomes. Investments in rural education infrastructure, teacher training, and technology are key to bridging the urban-rural divide. For example, Finland's education system prioritizes equity by allocating resources to underserved regions, offering a model to follow (Silliman and Virtanen, 2019).

## DATA AND METHODS

This research utilizes a dataset containing the annual count of students enrolled in daytime programs at secondary schools in Slovakia. The data is aggregated at the district level (79 districts) for three-time intervals: 2003, 2013, and 2023. These intervals correspond to the consistent territorial-administrative divisions established in 1996. In addition to student enrollment data, we extract key information on the number of secondary schools, which is crucial for assessing the competitive landscape among educational institutions within each district. The competition is primarily influenced by public stakeholders and self-governing regions, though private entities and church organizations are also becoming more prominent. To facilitate comparisons across districts and time periods, we normalize the data by calculating the number of students and schools per one thousand residents. This approach accounts for demographic changes, offering a clearer understanding of regional educational dynamics.

Within each district, we also calculate the proportion of specialized study programs, which cover areas such as the arts, agricultural sciences, technical sciences, security and military sciences, and medical sciences, alongside the dominant general education. However, practical specializations are often criticized by employers in the context of regional development, particularly in less developed areas. Graduates without specific, regionally applicable skills often pursue higher education outside their home regions and do not return, leading to a depletion of valuable labor resources in local economies. For our statistical model, we use a population framework based on age, with a particular focus on individuals aged 15 to 19. This age group is the primary driver of secondary school demand, with few exceptions. Therefore, our analysis centers on this demographic, examining how the distribution and specialization of secondary education align with the economic needs of different regions.

To further enhance our analysis, we incorporate the population density of these regions. This distinction between densely and sparsely populated areas is crucial as it allows for comparisons between large cities and their surrounding residential zones. In densely populated urban areas, such as the capital and regional centers, demand for education tends to be higher due to the concentration of the population. Conversely, in less densely populated peripheral areas, demand may be lower due to a smaller population, limiting the benefits of economies of scale. To improve the accuracy of our analysis, we replace the overall unemployment rate with a targeted unemployment rate focusing on individuals aged 15-24. This demographic includes those who have completed high school but choose not to pursue further education, often staying in their regions due to various constraints. In contrast, older individuals may relocate in search of employment opportunities, particularly in economically disadvantaged areas.

A key component of our model is measuring the proportion of university graduates in each district, based on census data from 2001, 2011, and 2021. This data helps us understand the educational level within a region, which impacts both local economic development and the labor market's ability to absorb high school graduates. It also reflects the structure of the local economy and influences the academic ambitions of secondary school students. Our analysis further incorporates regional economic data, organized into four sectors: primary (agriculture, forestry, and fishing), secondary (manufacturing, construction), creative (information, scientific, technical, and artistic services), and service (other service sectors). This classification allows us to examine how each sector influences educational outcomes and the local labor market, providing a clearer picture of how economic specialization affects educational needs and the alignment between educational outputs and regional labor market demands.

*Econometric panel approach with spatial effects*

This study uses a spatial econometric panel data framework to analyze secondary school enrollment in Slovakia's districts over two decades, considering spatial dependencies and unobservable district-level heterogeneity. The spatial error model (Millo and Piras, 2012) is well-suited to contexts with significant regional spillovers, capturing both spatial and temporal dimensions. The general model specification is as follows:

$$y = \lambda(I\mathrm{T} \otimes \mathrm{WN})y + X\beta + u$$
$$u = \lambda(\iota\mathrm{T} \otimes I\mathrm{N})\mu + \varepsilon$$
$$\varepsilon = \rho(I\mathrm{T} \otimes W\mathrm{N})\varepsilon + \nu$$

where $y$ represents the dependent variable (secondary school enrollment per 1,000 residents), $X$ includes the explanatory variables (e.g., demographic factors, curricular specializations, and economic conditions), $W$N is the spatial weight matrix capturing inter-district interactions, and $u$ denotes unobservable effects. The parameters $\lambda$ (lambda) and $\rho$ (rho) represent spatial autocorrelation in the dependent variable and residuals, respectively. The spatial weight matrix, based on contiguity, assumes interactions between neighboring districts. The random effects spatial error model explicitly incorporates error correlation across districts, addressing spatial dependence and unobservable district-level characteristics. Additional parameter $\phi$ (phi) quantifies spatial autocorrelation in enrollment outcomes, while $\rho$ (rho) captures the spatial dependence in residuals. By addressing these dependencies, the model reduces bias and enhances the efficiency of estimates.

To ensure the robustness and validity of our model, we performed specification tests. Lagrange Multiplier (LM) tests revealed significant spatial dependencies.

The LM1 test highlighted strong spatial lag dependence, while the LM2 test identified spatial error dependence. The conditional test for spatial error (CLMμ) confirmed significant error dependence, supporting the inclusion of spatial effects in the residuals. On the other hand, the conditional test for spatial lag (CLM$\lambda$) was insignificant, suggesting that spatial lag dependence is adequately captured without adding complexity. The Hausman test validated the use of the random effects specification, indicating that it yields consistent and efficient estimates in contrast to the fixed effects models employed in the initial experiments of this research. This finding strengthens the model's capacity to manage unobserved heterogeneity while preserving simplicity.

**Table 2:** The distribution of secondary school students in Slovakia.

| Variable | Description | Mean level | | |
|---|---|---|---|---|
| | | 2003 | 2013 | 2023 |
| **Students** | The district's secondary school student population per thousand residents. | 58.6 | 40.2 | 34.5 |
| **Demand side:** | | | | |
| **Age 15-19** | The percentage of individuals aged 15-19 years in the overall population of the district. | 8.0 | 5.8 | 5.0 |
| **Density** | The density of the population in the district, measured as the number of inhabitants per square kilometer. | 259.0 | 252.8 | 267.5 |
| **University** | The proportion of individuals with university degrees in the population of the district. | 7.3 | 13.2 | 17.3 |
| **Unemployment** | The percentage of individuals aged 15-24 who are registered as job seekers at employment offices, relative to the overall population. | 11.2 | 10.5 | 4.1 |
| **Regional economy** | | | | |
| **Sector I** | The proportion of the primary sector's contribution to the overall value added in the economic output of the region. | 2.4 | 3.0 | 2.9 |
| **Sector II** | The percentage of the industrial sector and construction industry's impact on the region's total value added. | 35.5 | 33.7 | 34.6 |
| **Sector III (Ref.)** | The portion of the service sector's involvement in the economic output value of the region. | 50.0 | 46.8 | 47.2 |
| **Sector IV** | The allocation of the creative sector's value added to the region's economic production. | 12.2 | 16.5 | 15.3 |
| **Supply side:** | | | | |
| **Competition** | Mean number of high schools per one thousand residents in the region. | 0.2 | 0.1 | 0.1 |

| Variable | Description | Mean level | | |
|---|---|---|---|---|
| | | 2003 | 2013 | 2023 |
| **Fields of specialisation (%)** | | | | |
| **Social (Ref.)** | Proportion of students enrolled in broad academic programs as well as in social sciences and humanities. | 58.6 | 63.8 | 57.9 |
| **Artistic** | Percentage of students pursuing cultural and artistic studies. | 2.1 | 3.4 | 3.2 |
| **Agricultural** | Distribution of students studying agricultural sciences. | 5.9 | 3.4 | 4.5 |
| **Technical** | Ratio of students enrolled in technical programs. | 31.4 | 27.1 | 30.6 |
| **Military** | Proportion of students pursuing security and military studies. | 0.0 | 0.0 | 0.5 |
| **Medical** | Share of students in health and nursing programs. | 1.9 | 2.1 | 3.3 |

The table outlines the breakdown for the years 2003, 2013, and 2023. The data is segmented based on educational fields, with explanatory variables representing various factors such as demographics, social aspects, and economic conditions that influence the demand side in statistical analysis.

*Source: Slovak Centre of Scientific and Technical Information (2024), Statistical Office of the Slovak Republic (2024a-e)*

## RESULTS

The random effects spatial error model incorporates two key spatial parameters. The parameter which measures spatial autocorrelation in the dependent variable, is significant, indicating that districts with higher secondary school enrollments tend to cluster spatially. This suggests the presence of regional spillover effects, where high-performing districts influence their neighboring areas, likely due to shared socioeconomic advantages or policy networks. In contrast, spatial dependence in the residuals is insignificant, indicating that once observable factors are accounted for, unobserved spatial correlation in the error terms diminishes. The significance pattern reinforces the robustness of the model, highlighting that regional disparities in educational outcomes are more driven by structural and demographic factors than by unaccounted latent spatial dynamics. This finding supports the model's ability to capture observable regional patterns while minimizing bias from spatial heterogeneity.

This discovery highlights the necessity for specific regional policies that tackle structural inequalities, as opposed to depending on generalized interventions. Table 4 presents the estimated coefficients for demographic, economic, and curricular predictors of secondary school enrollment. As expected, the proportion of youth aged 15-19 and population density emerge as strong positive predictors,

highlighting the importance of demographic and geographic factors. Districts with a higher concentration of youth and greater population density show higher enrollment rates due to economies of scale and better access to educational resources. Conversely, the proportion of university-educated residents negatively correlates with secondary school enrollment, suggesting that districts with higher educational attainment may face talent outmigration or shifts toward higher education pathways outside the region. This trend reflects concerns about rural-to-urban migration or outflow to foreign countries, further deepening regional disparities.

The results confirm that technical and medical specializations are positively associated with secondary school enrollment, reflecting their alignment with labor market demands and the growing emphasis on Industry 4.0 skills. Technical programs, in particular, exhibit the highest marginal effect among curricular tracks, emphasizing their significance for regional economic development. In contrast, agricultural and artistic programs show weaker or insignificant associations, suggesting potential mismatches with contemporary economic needs or limited student interest. These findings underline the need to tailor curricular offerings to

**Table 3:** Lagrange Multiplier and Hausman tests for spatial linkages and model specification

| | Statistic | p | Interpretation |
|---|---|---|---|
| Lagrange Multiplier tests | | | |
| LMH | 50.346 | 0.000 | Strong evidence of spatial autocorrelation in both the lagged dependent variable and spatial error. |
| LM1 | 6.234 | 0.000 | Strong evidence of spatial lag dependence. |
| LM2 | 3.388 | 0.001 | Strong evidence of spatial error dependence. |
| CLM$\lambda$ | 0.005 | 0.996 | No evidence of spatial lag dependence in the random effects model. |
| CLM$\mu$ | 6.939 | 0.000 | Strong evidence of spatial error dependence in the random effects model. |
| Hausman tests | | | |
| Lag | 2.381 | 0.999 | Random effects model is more efficient for the spatial lag model. |
| Error | 9.117 | 0.764 | Random effects model is more efficient for the spatial error model. |
| SARAR | 18.237 | 0.149 | Random effects model is more efficient for the SARAR model. |

This table presents the results of tests used to evaluate geographic linkages and the appropriateness of the random effects spatial error model. The tests reveal significant spatial error dependence and validate the efficiency of the random effects specification over fixed effects models for both spatial lag and spatial error formulations.

regional economic structures. For instance, modernizing agricultural programs to incorporate sustainability and advanced technologies could enhance their appeal and relevance, particularly in rural areas. The choice of a random effects spatial error model effectively captures the interplay between local and regional factors, offering insights into how these influences shape educational outcomes across districts.

By accommodating district-specific effects and recognizing spatial spillovers, this model highlights the importance of localized interventions tailored to both demographic and economic contexts. Economically, the clustering of high-performing districts around urban centers reflects broader agglomeration patterns, where concentrated resources and institutional networks drive superior educational outcomes. In contrast, peripheral districts face challenges linked to demographic decline and economic underdevelopment, as evidenced by weaker enrollment figures and the limited impact of certain specializations. The absence of significant residual spatial correlation further suggests that disparities are

**Table 4:** Estimated coefficients from the random effects spatial error model on secondary school enrollment.

| | Estimate | SE | t | p |
|---|---|---|---|---|
| Phi (ϕ) | 5.467 | 1.671 | 3.271 | 0.001 |
| Rho (ρ) | -0.038 | 0.174 | -0.216 | 0.829 |
| Intercept | 1.949 | 0.543 | 3.588 | 0.000 |
| Age 15-19 | 0.307 | 0.083 | 3.699 | 0.000 |
| Density | 0.212 | 0.038 | 5.620 | 0.000 |
| University | -0.204 | 0.054 | -3.810 | 0.000 |
| Unemployment | 0.019 | 0.022 | 0.848 | 0.396 |
| Sector I | 0.008 | 0.041 | 0.198 | 0.843 |
| Sector II | 0.041 | 0.107 | 0.378 | 0.705 |
| Sector IV | 0.158 | 0.088 | 1.799 | 0.072 |
| Competition | 0.540 | 0.042 | 12.854 | 0.000 |
| Artistic | 0.026 | 0.021 | 1.236 | 0.217 |
| Agricultural | -0.000 | 0.014 | -0.006 | 0.995 |
| Technical | 0.134 | 0.025 | 5.273 | 0.000 |
| Military | 0.025 | 0.030 | 0.823 | 0.411 |
| Medical | 0.105 | 0.027 | 3.924 | 0.000 |

This table presents the estimated coefficients from the random effects spatial error model analyzing secondary school enrollment. Key predictors include demographic, economic, and curricular factors, with spatial autocorrelation (ϕ) significantly influencing enrollment outcomes, while residual spatial dependence (ρ) is found to be negligible.

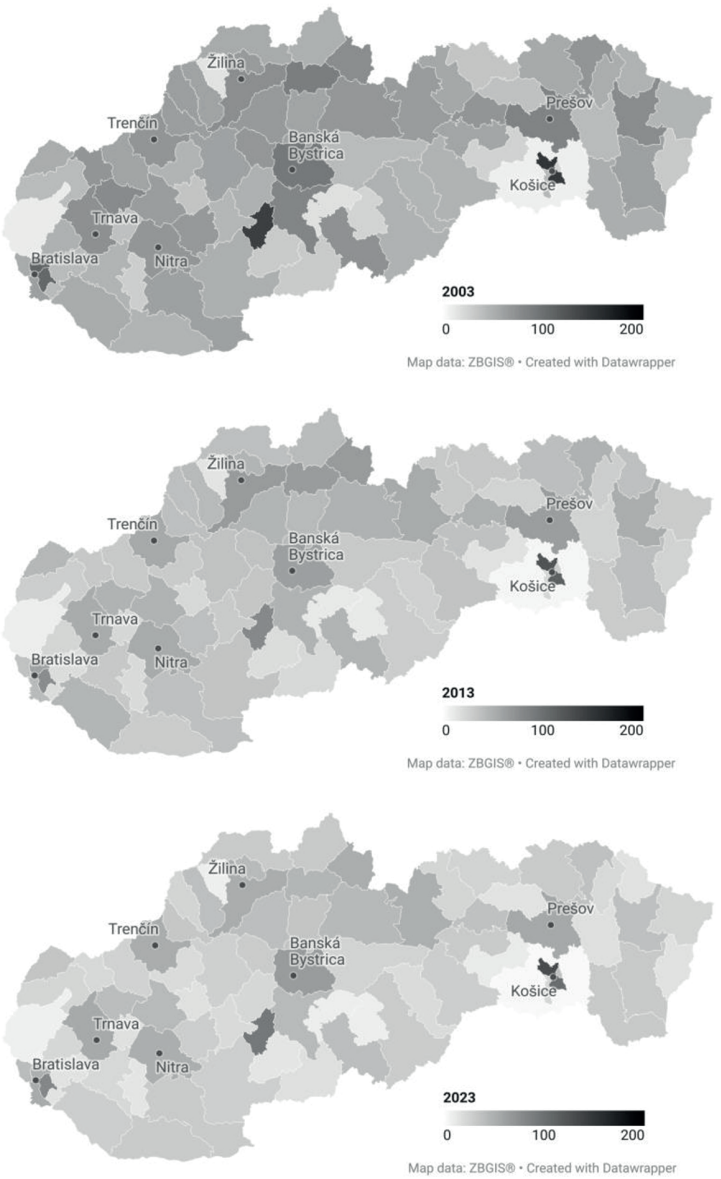


**Figure 1:** Spatial distribution of secondary school enrollment across Slovak districts (2003-2023)

This figure illustrates the spatial distribution of secondary school enrollment, highlighting a decline in the effectiveness of the education sector and an increasing divide, particularly between urban and rural areas. This trend poses a long-term challenge for regional development across various districts.

*Source: Slovak Center of Scientific and Technical Information (2024), Geodetic and Cartographic Institute Bratislava (2024)*

primarily driven by observable structural inequalities rather than unmeasured spatial dynamics. This finding emphasizes the need for targeted investments in underperforming districts, such as improving infrastructure, expanding technical and medical programs, and fostering partnerships with local industries to better align educational offerings with regional economic needs.

## DISCUSSION

The findings of this study provide insights into the spatial and demographic dynamics of Slovakia's secondary education system, highlighting regional inequalities that reflect broader socio-economic trends. The spatial clustering of high-performing districts, particularly around urban centers like Bratislava, demonstrates the role of resource concentration and institutional networks in fostering educational success. This observation aligns with Glaeser et al. (2011) and Florida et al. (2008), who emphasize the self-reinforcing advantages of urban areas in attracting talent and generating economic resilience. In contrast, rural and peripheral districts continue to grapple with demographic decline and underinvestment, which perpetuate regional disparities. The spatial autocorrelation parameter reveals that well-performing districts have a positive influence on their neighboring areas. However, the insignificance of residual spatial dependence suggests that unobserved factors, such as governance quality or informal networks, are less important than structural and demographic factors in explaining these disparities.

Demographic factors are critical drivers of secondary school enrollment, with population density and the proportion of youth aged 15-19 showing a consistent positive influence. These findings align with Szabo and Bleha (2018), who note how demographic decline in post-socialist countries exacerbates educational disparities, especially in rural areas. The negative correlation between the proportion of university-educated residents and secondary school enrollment is particularly significant. This suggests that districts with higher educational attainment may experience talent outmigration, either to urban centers or abroad, as noted by Bahna (2013). Talent outmigration weakens local labor markets and perpetuates inequalities by depleting already disadvantaged regions of valuable human capital. Addressing these demographic challenges will require targeted policies to encourage population retention in rural areas, such as affordable housing programs, tax incentives for young families, and improved local job opportunities.

Curricular specialization plays a crucial role in shaping enrollment trends. The pronounced positive impact of technical and medical programs illustrates their correspondence with labor market requirements and the transition towards Industry 4.0, as noted by Grenčíková et al. (2021) and Kovács and Domonkos (2024). This highlights the necessity of modifying secondary school curricula to meet

evolving economic demands, thereby equipping students with skills pertinent to rapidly expanding sectors. However, the limited impact of agricultural and artistic programs suggests a disconnect from contemporary economic realities and student interests. To improve their relevance, these programs could be updated to integrate modern advancements, such as sustainable agriculture practices or digital arts. This is especially important for rural regions, where agriculture remains a key economic driver, and adapting these programs could better equip students for future opportunities in these sectors.

The spatial patterns revealed by this study highlight the need for localized policy interventions. The clustering of high-performing districts suggests that targeted investments in infrastructure, teacher recruitment, and curricular modernization could help replicate these successes in underperforming regions. For example, digital education platforms and mobile learning units could bridge access gaps in remote areas, while partnerships between schools and local industries could align curricula with regional labor market demands. These strategies echo recommendations by Sutton (2017) and Silliman and Virtanen (2019), who advocate for stronger connections between education and industry to mitigate regional disparities. By fostering such partnerships, regions can enhance educational outcomes and address labor market mismatches, promoting more equitable development.

The implications of these findings extend beyond education, reflecting broader patterns of urban agglomeration where concentrated resources generate outsized benefits. However, this urban advantage could deepen rural disparities unless counterbalanced by targeted investments in outlying regions. Policymakers should prioritize equity-focused resource allocation to ensure rural schools can provide competitive educational opportunities. Strategies such as expanding transportation networks for better access to schools or subsidizing education costs for rural families could help bridge the urban-rural divide. Additionally, demographic stabilization policies, like offering relocation incentives for skilled teachers to underserved regions, could strengthen local capacities and reduce dependence on urban centers for educational and economic opportunities. These interventions can support a more balanced regional development, fostering economic resilience and equitable access to educational resources.

## CONCLUSION

This study emphasizes the pivotal role of education in shaping human capital and addressing regional disparities in Slovakia. By applying a random effects spatial error model, it reveals how demographic, geographic, and curricular factors interact to influence secondary school enrollment. The findings show significant spatial clustering of high-performing districts, especially around Bratislava, driven

by the concentration of resources and institutional networks. In contrast, rural and peripheral districts face ongoing challenges linked to demographic decline and economic underdevelopment. Demographic factors, particularly youth density and population structure, emerge as key drivers of enrollment, highlighting the importance of stabilizing younger populations in rural areas to maintain a robust education system. The positive influence of technical and medical programs emphasizes the need to align curricula with regional labor market demands, while the limited impact of agricultural and artistic programs calls for curricular modernization to address evolving economic needs.

The economic implications of these findings are significant. The clustering of high-performing regions highlights the self-reinforcing nature of urban advantages, where resource concentration and institutional networks create a cycle of success. Rural areas often face significant structural challenges, highlighting the urgent need for specific interventions. Initiatives designed to enhance digital learning access, improve transportation options, and cultivate collaborations between educational institutions and local businesses can effectively address the disparities between urban and rural settings, thereby advancing educational equity. This study ultimately reinforces the idea that education can serve as a powerful tool for economic and social equality. To tackle regional inequalities, it is essential to maintain a long-term dedication to policies that emphasize equity, which includes reallocating resources, updating educational curricula, and focusing on areas that are currently underperforming. By tailoring strategies to local contexts and leveraging spatial dynamics, Slovakia can ensure that all districts contribute to and benefit from national development. As the country transitions to a knowledge-based economy, investments in education will remain key to unlocking its full potential.

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# INVOLVEMENT OF FOODSERVICE ESTABLISHMENTS IN SHORT FOOD SUPPLY CHAINS: ORGANISATIONAL MODELS IN SLOVAKIA

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**Abstract**
In recent years, overseeing food systems has become a significant worldwide issue due to the climate crisis, biodiversity loss, and unhealthy diets. Short food supply chains are replacing conventional global supply systems by encouraging local and direct exchanges between consumers and producers. These systems provide urban areas with access to fresh, high-quality food while fostering community interaction and trust between producers and consumers. The food service sector acts as a key intersection in these regionalized systems by promoting local foods to customers and connecting with farmers and distributors. The article explores the involvement of food service establishments in regional food systems in Slovakia focusing on their organizational models. The presented outputs are part of a broader research aimed at exploring the potential of SFSC for the development of food service establishments. The research uses part of the primary data collected through an online questionnaire survey in Slovak food service establishments. Given the complex nature of SFSC and the largely unique nature of potentially created alternative food networks, our research design combines quantitative and qualitative methods. We used cluster analysis to identify and classify the forms of establishment involvement in SFSCs and to identify those more complex structures of regionalized food systems in Slovakia. Based on hierarchical clustering with Ward's minimum variance approach, 5 clusters that represent different models of involvement of food service establishments in SFSCs within regionalized food systems in Slovakia were profiled. Results show that an intermediary (local food center) can significantly support the involvement of food service establishments in the SFSC and take over the coordination of communication and logistics between farmers and food service establishments

in the territory. There are several studies on SFSC in the literature, but only a few deal with the involvement of food service establishments. The article examines the interest of Slovak food service establishments to participate in SFSCs, the existence of various organizational models of the SFSC involving establishments, and the challenges they are facing. At the same time, it opens up possibilities for a more detailed examination of the benefits and barriers perceived by food service establishments when participating in the SFSC.

**Key words**
Short food supply chain, local food system, food service establishment, organisational model, food distribution system.

## INTRODUCTION

In recent years, effectively managing food systems has become a major global challenge driven by the climate crisis, land degradation, worsening water quality, biodiversity loss, and the growing expansion of unhealthy diets (Rockström et al. 2020). Short food supply chains offer an alternative model to traditional global supply chains within agri-food systems. This model emphasizes local direct transactions between consumers and producers avoiding the lengthy networks and intermediaries typical for conventional global supply chains. Such systems include direct sales from farmers to nearby local retailers or consumers (Bakos 2017).

While short food chains may not fully replace global food systems, they offer numerous advantages. Local food systems help tackle urban challenges connected with access to high-quality and fresh food. Socially oriented short food chains enhance trust, interaction, and community cohesion and foster a closer link between production and consumption. They also contribute to knowledge sharing, which encourages changes in consumer behavior. Most importantly, they play a crucial role in building connections and trust between producers and consumers (Križan 2022). An important reason for supporting local food chains alongside global value chains in the agri-food sector is the environmental advantage of local food systems (Lochman, Vágner 2022). These systems contribute to soil preservation, biodiversity protection, and efforts to mitigate climate change (Edwards-Jones et al. 2008). Additionally, local food systems benefit local economies by boosting income and creating new jobs (Aguiar 2018; Falguieres 2015). These systems offer rural farmers opportunities for economic diversification, leading to higher incomes, better living standards and innovations in organization, processes and products or services. Such innovations can expand across various activities, support tourism development and enhance the region's image. In urban areas, food communities or health-focused groups benefit from the availability of fresh food (FAAN 2010). Consumer benefits within SFSC include obtaining important information and motivation driven by product quality (Lombardi et al. 2015; Stanco et al. 2019).

In these localized systems, the food service sector can play a pivotal role by fostering greater importance in local food among farmers, customers, and potential distributors. Key locations within the network are frequently linked to the growth

of supplementary activities such as gastro tourism, agrotourism and adventure tourism (Laginová et al. 2023). Numerous studies in the academic literature examine the advantages and disadvantages related to local food sourcing by food service establishments. The authors identify several key benefits including support for the local community and economy, safer and fresher food, superior product taste, improved public relations and increased customer satisfaction (Dougherty et al. 2013). Additional advantages include the ability to buy smaller quantities, reduced energy and transport costs, awareness of the origin and methods of production of products, natural food quality and environmental advantages resulting from the reduced distances between farms and food service establishments (Khan, Prior 2010).

## OBJECTIVES

This article examines the implications and dynamics of regionalized food supply chains in relation to foodservice establishments within Slovakia. The research questions are articulated as follows:

1. To what degree and in what ways do food service establishments engage in regional and local food systems in Slovakia?
2. What is the structure and organizational model of short food supply chains in which food service establishments participate?

## SHORT FOOD SUPPLY CHAINS AND LOCAL FOOD SYSTEMS

There are multiple definitions of SFSCs based on different criteria including the distance, amount of intermediaries, social interactions, knowledge exchange, location, and participation in governance (Jarzębowski et al. 2020). In general, short food supply chains (SFSCs) are defined as supply chains that involve a minimum amount of intermediaries. In the case of direct sales, they do not even include any intermediate link between the producer and the consumer. SFSCs were defined for the first time in the framework of the EU rural development policy for 2014-2020 as supply chains that involve a limited amount of economic actors that are ready to cooperate, support local economic growth and maintain close social and geographical ties among food producers and consumers and processors. Many authors have highlighted the numerous advantages brought by SFSC in the economic, social and environmental fields but also about possible barriers and opportunities for the development of SFSC (Coelho de Souza et al. 2021; Enthoven, Van den Broeck 2021; Jarzębowski et al. 2020). Products (Branding and Labelling, Valorization, Value), governance (external and internal), organizational/institutional systems (Networking, Cross-learning, Process Innovations), and sales (efficiency, diversity, and connection) are currently considered to be significantly discussed topics in connection with the SFSC (Jarzębowski et al. 2020).

Compared to SFSC, the definition of local food system (LFS) is more difficult. There is no unified consensus among the experts about what can be considered "local" or what creates a LFS. Most definitions focus on the general concept of the origin of local food (Dunne et al. 2014; Roy, Ballantine 2020) emphasizing the distance between the production site and the point of sale (Augère-Granier 2016). The geographical definition of LFS, which can be perceived differently for different types of food - from the local through the regional to the national level, is important. According to a report by the Joint Research Center (2013), a LFS is characterized by food being produced, processed and sold within a specific geographical area, typically within a radius of 20 to 100 km, depending on the source. In addition to spatial proximity (actual distance between food consumption and production), a LFS may also rely on relational proximity (e.g. strong connections between participants in the food system) and value of proximity (e.g. considerations of origin, freshness, traceability and quality). Local food is also a subjectively understood term and there is no unified definition of what constitutes local food. How the term "local" is understood depends on the context. Nummedal, Hall (2006) perceive local foods and beverages as specialties that have a local identity, including locally produced and regionally branded products. These include not only locally grown products but also raw materials originating from another area processed locally, thereby acquiring a local or regional identity (Matlovičová 2024). Hall et al. (2013), Roy, Ballantine (2020) state that despite the lack of a consistent definition of 'local food', it remains a significant part of promotion, purchasing, food branding and comprehension. The preparation of meals from local ingredients, the use of autochthonous varieties of fruits and vegetables as well as craft techniques in preparing meals are important gastronomic trends in restaurants (Pellešová, Vacha 2023), attracting more and more customers. At the same time (Lochman, Vágner 2021) also draws attention to the risks associated with a high concentration of catering establishments in tourism destinations (e.g. reduction of the area of agricultural land, food consumption, high intensity, etc.) and their limited impact on the sustainable development of the territory.

## TYPOLOGY OF SHORT FOOD SUPPLY CHAINS AND LOCAL FOOD SYSTEMS

Researchers and practice (Chiffoleau, Loconto 2018; Bertazzoni et al. 2020; Jarzębowski et al. 2020; Kneafsey et al. 2013; Laginová et al. 2023) have identified different types of SFSCs and use different classifications that take into account the number actors involved in SFSC on the side of producers or consumers (individual direct sales, collective direct sales or partnerships), relationships between them (formal/informal, binding/non-binding, personal/mediated, etc.), different organizational models and food distribution channels (farm direct sales, box sales, farm stores, farmers markets, community supported agriculture, online food sales,

etc.). Augère-Granier (2016) distinguishes between traditional and neo-traditional SFSC. *Traditional SFSC*s are typically based on farms in rural areas and often involve on-farm sales through farm shops, mobile sales and pick-your-own systems, and producer markets. These chains are usually managed by farming families and often utilize traditional and artisanal techniques. In contrast, *neo-traditional SFSCs* are more intricate systems that comprise cooperative networks of producers, consumers, and institutions while often striving to preserve traditional agricultural practices through innovative models and social changes. Examples consist of: supply schemes, urban farm shops and collectively owned farming systems, typically situated in urban areas or on the city's outskirts. They are considered to be local food movements often driven and supported mainly by urban inhabitants.

The majority of authors describe SFSCs as the main type of distribution channels applied in LFS. A characteristic feature is the reduced number of intermediaries between producers and consumers. Nevertheless, it is necessary to distinguish between SFSC and LFS because SFSC does not have to be local and LFS does not necessarily include SFSC (Enthoven, Van den Broeck 2021). Within the SKIN (Short Supply Chain Knowledge and Innovation Network) project, the authors distinguished LFS (operating based on SFSC) into three categories: local food systems, hyperlocal food systems and ultralocal food systems. The traditional definition of SFSC encompasses actors operating in *local* food systems, typically situated in rural areas near a larger city or town, who seek to enhance their income by functioning as both processors and retailers (Jarzębowski et al. 2020). Enthoven, Van den Broeck (2021) highlighted the region's potential for self-sufficiency that could be attained by aligning agricultural practices with local and regional requirements and encouraging dietary choices towards regional and local products. *Hyperlocal* food systems encompass SFSCs typically situated in rural areas close to cities and typically engage in production, processing and marketing. This broader perspective also includes traditional urban farming activities aimed at producing fresh fruits and vegetables that have been enhanced through technological advancements (Jarzębowski et al. 2020). *Ultralocal* food systems cover hobby gardens which often provide individuals with ample food to cultivate for personal consumption, to share with neighbors, or to sell at small markets. Many cities and towns endorse this practice not only as a strategy for food security but also as a means to enrich community life by fostering connections among neighbors (Jarzębowski et al. 2020).

Distribution channels in LFS are organized in different ways, based on different types of sales agreements among producers and buyers, the forms of interaction between consumers and producers and the varying levels of consumer commitment (Enthoven, Van den Broeck 2021).


**Fig. 1** Local food distribution channels
*Source: Self-elaborated based on Enthoven and Van den Broeck (2021)*

Enthoven, Van den Broeck (2021) divided LFS into three groups (figure 1). *The first group* consists of direct sales to the consumer and is also one of the forms of SFSC. The group includes sales through farmers' markets, on-farm sales, delivery sales (boxes, cases, pick-up point) and community supported agriculture. In this LFS, sales are carried out for standard prices, based on agreements between the producer and the buyer on the spot market or repeatedly based on a mutual agreement for standard prices or based on contracts for future repeat sales. Direct sales are based on a personal or close relationship, a so-called face-to-face interaction between producer and consumer (Holloway, Kneafsey 2000; Pretty 1998). The consumer undertakes to purchase food only in case of delivery sales and community supported agriculture. In other cases of LFS, the consumer's commitment to the producer is low. *The second group* of LFS are direct retail SFSCs. Sales in this group are made through consumer retail cooperatives, local independent retailers, restaurants, other foodservice establishments, and institutions like schools and hospitals (Marsden et al. 2000; Renting et al. 2003; Schönhart et al. 2009). These SFSCs are based on mutual formal contracts between producers and buyers. They do not involve interaction with the consumer. They assume production and sales in the same place. According to Banks (2001), in this group of LFS, the most common cooperation occurs among producers who, for instance, broaden their offerings by exchanging products between farm shops or by combining individual items under a regional quality brand. LFS are primarily based on spatial proximity with products being sold in the region (or area) where they are produced, and consumers (including tourists) being made aware of the "local" characteristics of the product at the retail site. *The third group* of SFSCs, according to the authors Enthoven, Van den Broeck (2021), is represented by supermarkets and large food retailers who, despite being considered conventional supply chains, also acquire local food. Several international supermarket chains declare their commitment to local farmers and have formal mutual agreements with them to sell their products. Interactions between the producer and the consumer can be spatially extended. It means that consumers also buy foods that

are not produced locally, but their origin and producer are indicated as regional brands. These global networks can still be considered "short" food supply chains: the crucial factor is not the distance the product travels, but rather the valuable information it carries when it reaches the consumer, such as details printed on the package or communicated at the point of sale. This allows consumers to connect with the place of production and possibly with the values of the individuals involved and the methods used in production (Whatmore, Thorne 1997).

The image of products and the production area (Place Image) Matlovičová (2024) are key aspects for building LFS, strengthening trust between farmers and restaurant operators and for their motivation to buy local food. These are often more important than other objectively non-existent attributes because place identity and place image add value to local production. From the point of view of effective management and sustainability of the SFSC, marketing communication and branding of individual actors, as well as production and consumption locations, are important in increasing the bargaining power of the associated actors.

## FOOD SERVICES IN LOCAL FOOD SYSTEMS

Businesses providing catering services (restaurants, buffets and catering companies) that operate in the field of food and beverage production and distribution also have their place in SFSC and LFS. These food establishments represent actors in the food system and create an aggregate demand for larger volumes of food compared to individual household consumption (Paciarotti et al. 2022; Pugas et al. 2023, Malachovský 2021). The growth in the volume of demand for food produced within the SFSC simultaneously supports the expansion of food production by local or regional producers and creates more space for the adaptation of more farms to a more sustainable way of production. Hyland, Macken-Walsh (2022) point to the involvement of foodservice establishments in SFSC using the example of a social network in the Kempen region (Belgium). This network is based on connecting farmers (producers) with businesses such as retail stores, hotels, foodservice establishments, and specialized stores and farm shops through the food center "Distrikempen", which serves as an important intermediary between the mentioned entities. The benefits of cooperation between farmers and restaurants with a local food center are also pointed out by Paciarotti et al. (2022). They see the local food center as a "hub" and transshipment platform where food products from various suppliers are received and consolidated and then delivered to restaurants.

Enthoven, Van den Broeck (2021) consider foodservice establishments as an important part of local food systems, which are based on a contractual basis between producer and establishment and close interaction between producer and consumer. Roy et al. (2017) emphasize the importance of personal relationships and building trust between farmers and restaurant operators for their motivation to buy local food. Pugas et al. (2023) addressed in their case study in Florianópolis (Brazil)

the potential and conditions for the involvement of foodservice establishments in SFSC initiatives. The research showed that foodservice establishments consider the affordable price of products (42%), delivery guarantee (26%), product quality (22%), the need for delivery to the place or close to the business (19%), and adequate payment to be necessary conditions for participation in SFSC conditions (16%). Restaurants and chefs play a crucial role in the food distribution system allowing them to foster greater interest in local foods among their customers as well as the farmers and distributors from whom they source their products (Roy, Ballantine 2020). Restaurants generally align with consumers on the primary advantages of purchasing local food: strengthening the local economy and community, enjoying fresher and safer food, experiencing superior taste, maintaining good public relations and achieving higher customer satisfaction. Additionally, they appreciate the ability to purchase smaller quantities, reduced transportation distances and lower energy consumption, as well as having knowledge of product origins and production methods. They also perceive the cost savings, natural quality of food and environmental benefits resulting from a shorter distance between farms and restaurants (Roy, Ballantine 2020). For farmers, the inclusion of restaurants in the LFS, in addition to increased sales of their products in terms of quantity and price also means the opportunity to sell food with a short shelf life, which would otherwise expire during the seasonal period.

Managing LFS (involving farmers and restaurants) is challenging. Some studies report that communication problems arise between farmers and restaurants and point to a lack of knowledge about the availability of local products (Paciarotti et al. 2022; Sharma et al. 2014). Other authors draw attention to the restricted availability of local products regarding both quantity and variety throughout the year (Kang, Rajagopal 2014) and logistical problems. These are mainly related to the transportation of small volumes of food, the required high frequency of deliveries, the large number of recipients and the irregularity of distribution (Paciarotti et al. 2022). Solving these problems requires choosing the right LFS model or optimizing the existing model. Paciarotti et al. (2022) in their research examine different SFSC models involving restaurants from a logistics point of view. They divide the SFSC models with the participation of restaurants into two groups. The first group is represented by a model based on a direct farmer-restaurant relationship (or with the involvement of a virtual platform that ensures communication of orders between farmers and restaurant operators). Two logistics scenarios are included in this group: "transportation of products is provided by producers who deliver to restaurants that have ordered from them" and "transportation of products is provided by restaurants that collect products from producers that they have ordered from". The second group is represented by various forms of SFSC (authors mention scenarios) involving the local food center (intermediary). The local food hub provides logistics services to all participating farmers and restaurant operators.

*Scenario a)* represents the transport of products from farms to the food center by farmers and transport from the food center to restaurants by restaurant operators. In *scenario b)* the collection of food from farmers is ensured by the food center, and the restaurant operators pick up the products at the center individually. In *scenario c)* the situation is the opposite – farmers transport products from the farm to the food center individually, and the food center will ensure delivery of the products from the center to the restaurant. In *scenario d)* product distribution is provided both ways by the food center. Based on the simulation of different situations (number and structure of actors, their geographical distance, location of the food center), the authors identify the optimal food distribution system in the SFSC. Despite the obvious benefits resulting from the involvement of foodservice establishments in SFSC, few studies (Pugas 2023) deal with this issue in the professional literature, especially the involvement of privately owned businesses in SFSC.

## DATA AND METHODS

This study aimed to identify the forms of involvement of foodservice establishments in SFSCs and to explore more complex cooperative structures as the basis for regionalized foodservice systems in Slovakia. The research utilizes part of the primary data collected using an online questionnaire survey involving Slovak foodservice establishments. Considering the complex nature of SFSCs and the largely unique character of potentially established alternative food networks, our research design combines elements of quantitative and qualitative methods. The questionnaire survey was designed to capture experiences emerging from the foodservice establishment perspectives regarding their involvement in SFSC, the cooperative structures that influence these supply chains, perceived benefits and barriers and the motivations behind their participation.

We utilize cluster analysis to identify and classify potential local food system structures and related foodservice establishment forms of SFSC involvement. Cluster analysis results are confronted with answers of the respondents to open-ended questions describing the supplier-customer structures in which they are involved and their functioning. Based on these findings, we define the organizational models of short food chains in the conditions of Slovakia. Utilized data is part of a more broadly formulated questionnaire survey aimed at mapping the involvement of commercial foodservice establishments in short food chains, identifying cooperative structures of local food networks and hypothetical interest of foodservice establishments in sourcing local foods in the conditions of Slovakia. The survey included open-ended questions to enable respondents to provide detailed accounts of their involvement and the cooperative frameworks in which they operate. We utilize data on the foodservice establishment (establishment location, engagement in agricultural production or agro-tourism services), the structure of the existing supply chain (existing suppliers, logistics capabilities) and

involvement in SFSCs. The questionnaire survey was distributed to food service establishments across Slovakia with contact information sourced from a publicly accessible online database of such establishments. Out of 3,876 email addresses, 832 were invalid. The questionnaire was refined after consultations with 3 experts on tourism, gastronomy, and the food industry. The questionnaire was distributed electronically through the Google Forms service. The data was collected from March 2024 to May 2024. The questionnaire was filled out correctly by 158 respondents. Considering the valid email addresses, the response rate was 5.19%.

To assess the representativeness of the full dataset (n=158) (Tab. 1), we consider the population to be the number of establishments listed in the online database of foodservice establishments. In terms of regional distribution, the sample overrepresents the Nitra region while underrepresenting the Bratislava and Košice regions. The representativeness in other regions varies but is generally closer to the population distribution. For the size of establishments, data for the population at the establishment level were not available, so we used data from the Slovak Register of Economic Subjects, specifically for establishments whose main activity is Accommodation and Food Services. The survey sample shows a bias in the size distribution of establishments with a substantial overrepresentation of

**Tab. 1** Characteristics of the sample

| | Sample (n=158) | Population |
|---|---|---|
| ***Number of employees*** | | |
| 0 to 9 employees | 48,41% | 94,20% |
| 10 to 49 employees | 49,68% | 5,31% |
| 50 to 249 employees | 1,91% | 0,45% |
| 250 and more employees | 0,00% | 0,04% |
| ***Regional distribution*** | | |
| Banskobystrický | 14,56% | 13,48% |
| Bratislavský | 5,70% | 15,51% |
| Košický | 3,16% | 11,42% |
| Nitriansky | 38,61% | 12,05% |
| Prešovský | 7,59% | 13,40% |
| Trenčiansky | 10,13% | 11,45% |
| Trnavský | 10,13% | 8,97% |
| Žilinský | 10,13% | 13,71% |
| ***Municipality*** | | |
| Urban | 67,72% | 81,66% |
| Rural | 32,28% | 18,34% |

*Source: own processing (2024)*

organizations with 10 to 49 employees. However, the population in this case may not reflect the specific situation of foodservice establishments, and we assume that the size category of 10 to 49 employees is characteristic for this type of establishment.

### Cluster analysis

Cluster analysis was applied as a tool to identify and classify the forms of involvement of establishments in SFSCs, and to identify the structures of regionalized food systems in Slovakia. The basis for the cluster analysis was the respondents of the questionnaire survey involved in SFSCs. Although the questionnaire included several questions outlining the forms of involvement in SFSCs, the criterion was the mention of at least one specific regional supplier. This was justified by the importance of identifying the location and type of supplier, as the distance of the foodservice establishment to suppliers was considered a crucial factor defining the SFSC operating model. For the suppliers specified in the survey, it was manually verified whether they could be considered part of the SFSC. Out of 276 specified suppliers, 140 were excluded. These were suppliers within global supply chains (primarily conventional wholesalers and retail chains) and businesses that could not be identified. In 16 cases, the description confirmed that it was a regional supplier, but their trade name and location were not provided. At least one regional supplier was identified for 70 foodservice establishments, and these observations formed the dataset for the cluster analysis. Based on the literature, the classification factors were population density in the location of the establishment, involvement in own agricultural activities, median distance to regional suppliers, type of suppliers, form of involvement in SFSC, and capability of using own transport vehicles. The distance between establishments and suppliers was calculated using *osmnx* and *networkx* Python packages, using OpenStreetMap street networks as the shortest distance via the road network. An overview of cluster analysis variables is presented in Tab. 2. Descriptive statistics for the included variables are presented in Tab. 2.

The analysis was conducted in R software, using the *cluster* package (Maechler et al. 2023). Since the dataset contains mixed data types, we used Gower distance (Ranalli, Rocci 2021). Hierarchical clustering with Ward's minimum variance method was chosen due to its ability to create well-separated clusters and its suitability for smaller datasets (Jaeger, Banks 2023). Due to the skewness of the data distribution for *pop_density* and *median_distance*, we log-transformed these indicators. The data were standardized. The dataset did not contain any missing data. The optimal number of clusters was selected based on multiple methods using a consensus-based algorithm with the *NbClust* package (Charrad et al. 2022). The majority of methods (23.08%, 6 out of 26) recommended choosing either 2 or 5 clusters. To provide a deeper understanding of the establishment's SFSC involvement patterns, we opted for 5 clusters as the optimal number.

**Tab. 2** Overview of cluster analysis variables

| Variable name | Description | Type | Source |
|---|---|---|---|
| ln(pop_density) | Population density at the municipality level. Log transformed | continuous | Statistical Office of the Slovak Republic (2024) |
| agro_production | 1 = The establishment engages in its own agricultural production or offers agro-tourism services. | binary | survey |
| ln(median_distance) | Median distance of the establishment to local suppliers via road network in km. Log transformed | continuous | survey, own calculation |
| supplier_producer | 1 = The establishment obtains products from at least one supplier classified as an SFSC producer. | binary | survey |
| supplier_processor | 1 = The establishment obtains products from at least one supplier classified as an SFSC processor. | binary | survey |
| supplier_intermediary | 1 = The establishment obtains products from at least one supplier classified as an SFSC intermediary. | binary | survey |
| sfsc_farm_gate | 1 = The establishment obtains products through farm gate sales and self-picking | binary | survey |
| sfsc_fm_shop | 1 = The establishment obtains products through farmer's market shops. | binary | survey |
| sfsc_local_market | 1 = The establishment obtains products through local markets. | binary | survey |
| own_transport | The ability of the establishment to use its own vehicles for transporting SFSC-related inputs (0-4 scale) | ordinal categorical | survey |

*Source: own processing (2024)*

## RESULTS AND DISCUSSION

### Profile of foodservice establishments and their involvement in the regional and local food system in Slovakia

In the case of the full dataset (n=185), most foodservice establishments focus on Slovak cuisine (75.3%) and Central European cuisine (45.6%), reflecting the local culinary tradition. Other popular cuisines include Italian and American, featured in 34.2% and 20.3% of the establishments, respectively. The employed communication strategies to attract customers mainly focus on a favorable price-quality ratio (81.6%). A comprehensive menu offering is the next most common strategy,

adopted by 39.2% of the restaurants. Traditional cuisine is featured in the communication strategy of 34.2% of the establishments, followed by an authentic dining experience using local ingredients (19.6%). Regarding the target groups of establishments, the largest group is individuals with any income level (81.0%). Families with children are another significant target group (65.8%). Young people are targeted by 59.5% of the establishments.

We identified 136 specific foodservice establishments and suppliers that have the character of short food supply chains. Outside of the identified pairs, respondents in 21 cases refused to mention specific suppliers. The reason was that there were various forms of sourcing from small growers or individuals selling surplus production and operating outside the "system." Legislative and hygienic conditions for local sourcing in Slovakia are strict, creating room for the informal economy. Therefore, we assume that a significant share of deliveries with the character of short food supply chains in Slovakia is carried out outside of official records.

Among the identified suppliers, most are producers (63.97%), with processors and intermediaries being less numerous (22.79% and 13.24%, respectively). Most distances to producers are relatively short (figure 2), with many values clustering below 50 km. However, there are several outliers with very long distances, indicating that some producers are located quite far from the establishments they supply. Compared to producers, processors tend to be located relatively closer to foodservice establishments. This could be due to the more centralized nature of processing facilities, which might be strategically located to serve multiple restaurants efficiently. Intermediary distances suggest a bimodal distribution, with a cluster of short distances below 50 km and several much larger distances. There are a few significant outliers with intermediary distances extending beyond 200 km, indicating that some intermediaries operate at a considerable distance from the foodservice establishments. The presence of intermediaries located far away might indicate that these entities aggregate products from various producers and distribute them over larger distances, potentially to ensure a diverse supply of products. The spatial distribution of the analysed pairs of foodservice establishments and their suppliers is shown in figure 2.

Involvement of foodservice establishments in various forms of short food supply chains is shown in figure 4. A significant portion of establishments (32.0%) source their ingredients directly from farm gates. Nearly a third of the establishments (31.1%) obtain their inputs from farmer's market shops. Similarly, 30.3% of establishments source their produce from local markets. A small percentage of restaurants (4.10%) engage in self-picking. This method of involvement is naturally limited by the type of inputs and influenced by seasonality. It is labour-intensive and time-consuming, especially for larger establishments, they cannot systematically ensure sourcing in this way. Only a small fraction of restaurants

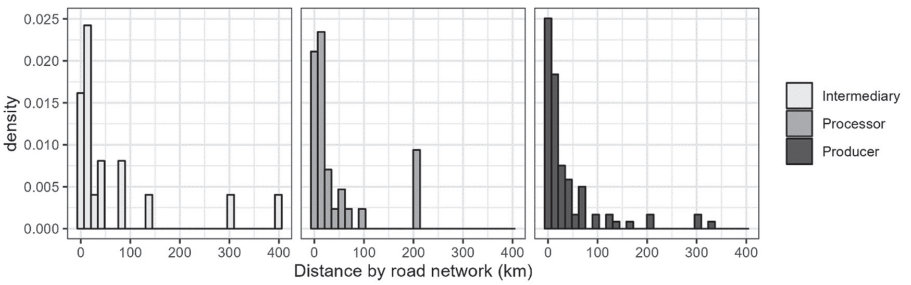


**Fig. 2** Distribution of spatial distances to a SFSC supplier
*Source: edited by the authors (2024)*

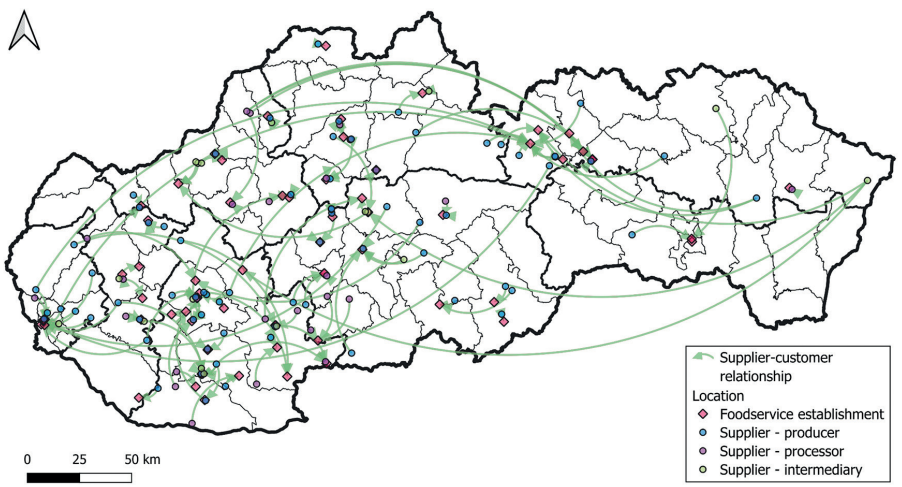


**Fig. 3** Spatial distribution and supplier-customer relationships of foodservice establishments and their suppliers
*Source: edited by the authors (2024)*

(2.46%) use box delivery schemes. The low proportion suggests that this method is not widely adopted, possibly due to logistical challenges or the specific needs of the restaurants not aligning well with this type of delivery. Coordinating deliveries to ensure they align with restaurant schedules can be challenging, particularly for perishable items that require timely delivery. Fixed schedules of these schemes might not align with the dynamic needs of restaurants that may require last-minute supplies. Availability of certain products may be highly seasonal, leading to inconsistency in ingredient supply throughout the year. However, we consider the main reason for the low involvement in this type of short food supply chain to be that such schemes are largely not yet established in Slovakia. A portion of the establishments (17.72%) were involved in multiple forms of food sourcing

within the SFSC. Farm gate sales are frequently combined with other sourcing methods, particularly with local markets (12 co-occurrences) and farmer's market shops (11 co-occurrences). Farmer's market shop is also commonly combined with other methods, especially with local markets (14 co-occurrences). This indicates that foodservice establishments engaging in farm gate sales are versatile in their sourcing strategies. From the perspective of utilizing farmer's market shops, utilizing this form in conjunction with others may contribute to a higher variety of available products.

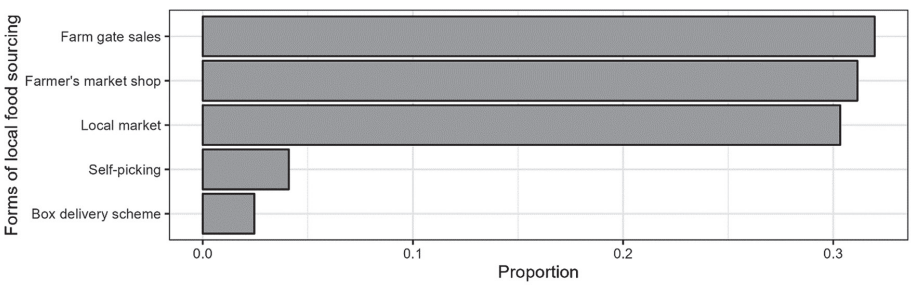


**Fig. 4** Involvement of foodservice establishments in SFSC
*Source: edited by the authors (2024)*

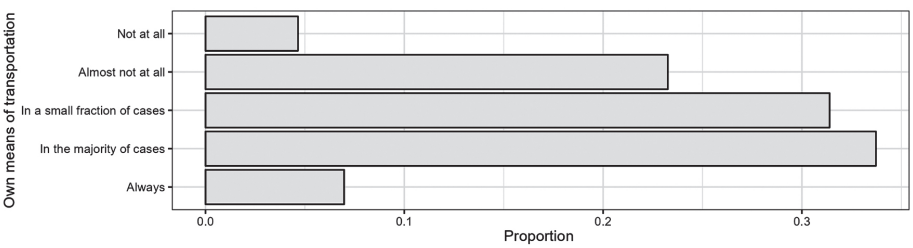


**Fig. 5** Capabilities of using own transportation means
*Source: edited by the authors (2024)*

Foodservice establishments involved in SFSCs (n=86) rely heavily on their own transportation means, with up to approximately 72% of them using their own transportation in at least a small fraction of food deliveries made (figure 5). More than a third of them use their own transportation in the majority of food deliveries made. The higher percentage of establishments involved in SFSC using their own transportation suggests that they cannot rely on established distribution networks provided by larger suppliers and wholesalers. The reliance on own transportation in case of facilities involved in SFSC may reflect the need for flexibility and responsiveness in handling local produce and prioritization of direct control over their supply chains. However, we assume that this indicates the absence of more

comprehensive distribution systems in the form of networks of cooperation among producers, consumers and institutions. It suggests the prevalence of individual direct sales to restaurants, which rely on their own transportation. The inability to ensure own transportation thus appears to be a significant barrier to participating in SFSC under the conditions in Slovakia.

### Organisational model of involvement of foodservice establishments in SFSCs

The purpose of cluster analysis was to identify the forms of involvement of foodservice establishments in SFSCs and identify more complex cooperation structures as the basis for regionalized food systems in Slovakia using a subset of 70 establishments with identified SFSC suppliers. Based on hierarchical clustering using Ward's minimum variance method, the analysis resulted in five clusters. The dendrogram and heatmap are shown in figure 6.

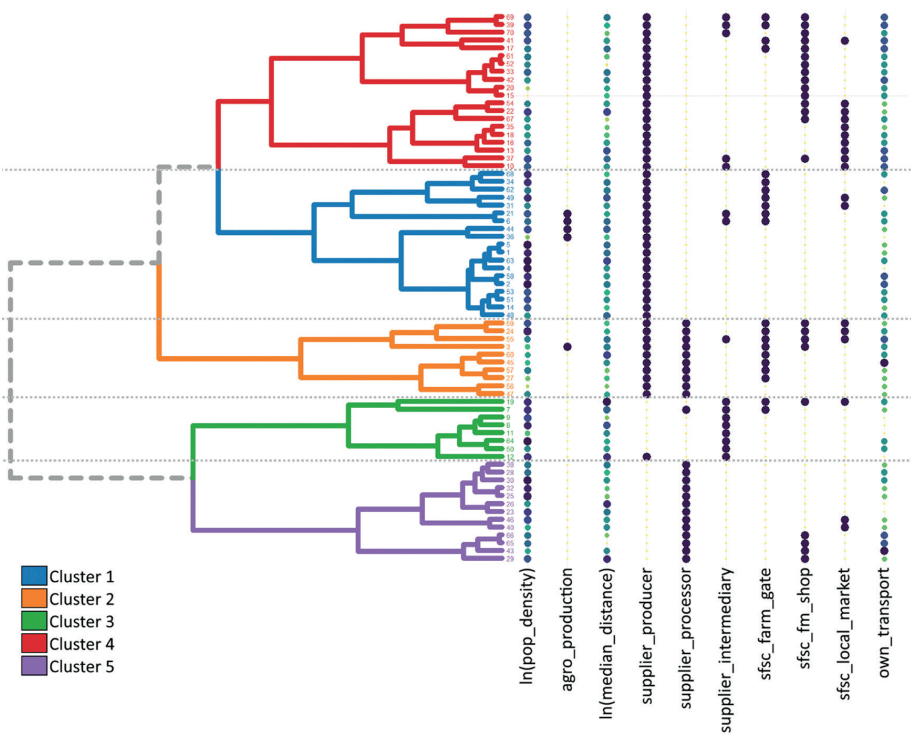


**Fig. 6** Cluster analysis dendrogram and heatmap
*Source: Self-elaborated based on R software (2024)*

Based on the cluster analysis, 5 clusters were identified, which represent different forms of involvement of foodservice establishments in the SFSC within regionalized food systems in Slovakia. These differ from each other in their location, the use of their own food production, the method of involvement in SFSC or organizational model of the SFSC, the distance of the suppliers who supply foodservice establishments and ensuring the transport of products from the supplier to the facilities.

*M1 - Model "direct sale farmer-restaurant in the city" (19 establishments)*

Foodservice establishments are mainly located in the city. A typical feature of this group is that they buy the local/regional products that they use in the preparation of food and drinks in their establishment directly from the producer (farmer). Some of them grow their own products, have animal production, or provide agro-tourism services. A characteristic feature of the entire group of establishments is the relatively greater distance from the supplier of raw materials for the preparation of food and beverages (more than 24 km in most establishments). None of the establishments buy products from the processor, in farm shops and only a very small part from the intermediaries or at the local market. Part of the facilities uses self-harvesting to ensure the supply of fruit and vegetables. This is the model identified by Paciarotti et al. (2022) as a model of "direct sales from farmer to restaurant" with the use of product transport provided by both the farmer and the restaurant. A greater distance between the supplier and the customer indicates that it is a spatially extended relationship between the producer and the foodservice establishment - the consumption of local products is also realized outside the territory of the location/region (Renting et al., 2003). The group includes innovative enterprises that support social and technological innovations in LFS. An interesting example is LFS based on community supported agriculture. It is a replicable model of a small family farm (2ha) that supplies a closed group of regular customers (including restaurants). The farm uses a special technology for plant care and soil treatment, the so-called agrokruh, is able to produce 24 tons of vegetables per year with a large variety of products. The products are grown by the farmer according to the customer's interest. The circle also symbolizes (in addition to the technological meaning) the matching of supply with demand and the agreement between the farmer and the customer (in our case, a restaurant in the city). A similar example of a functioning LFS is the cooperation of gastronomic enterprises with micro farms, which offer the possibility to subscribe to seasonal boxes of delivered food in regular delivery cycles to the establishment. In addition to food deliveries, they also offer educational excursions, team building, cooking courses, or experiential fine dining. An innovative example of LFS is the supply of a restaurant in the city by a civic association that brings together a community of edible mushroom growers

in an urban environment. The association strives for their popularization and use in gastronomy, science and art.

*M2 - Model "direct sale farmer/processor - restaurant in the countryside" (10 establishments)*

Foodservice establishments are mainly located in the countryside. A characteristic feature of this group is (similarly to the 1st group) that they purchase local/regional raw materials for the preparation of food and drinks directly from producers but also from processors in the immediate surroundings (within 10 km). The range of food also corresponds to the short distance. The majority of establishments purchase products of regular consumption that require frequent supply (e.g. vegetables, fruit, herbs, meat, milk, eggs, fish, mushrooms, bread and pastries, etc.). In rare cases, especially with commodities such as game or cheese, the distance is longer. This group also uses direct yard sales and/or self-picking. To a lesser extent, establishments also use farm shops and local markets when purchasing raw materials. The owners of establishments of this group boast about the freshness and quality of the ingredients, the prompt deliveries from local farmers and the "above standard" relations with farmers. Supply of products is based on telephone or electronic order and delivery of products is by farmers. In this case, it is the traditional model of direct selling in SFSC (Enthoven, Van den Broeck 2021), which involves actors operating in local food systems, typically located in rural areas near larger towns or cities, aiming to increase their income by functioning as both processors and retailers (Jarzębowski et al. 2020). This group includes gastronomic establishments that buy from farmers who simultaneously fulfill the role of the producer and the processor, and/or have a network of their own retail stores and support the "farm to table" initiative. They use mobile app to support the sale of food by delivery.

*M3 - Model "farmer - intermediary - restaurant in the city" (8 establishments)*

The foodservice establishments of the 3rd group are mainly located in the city. In the distribution chain, they buy exclusively from an intermediary and they are not food producers (i.e. they do not grow any products and animals). They buy products from more distant suppliers (median 35.7 km). For special products, the distance is greater, exceeding 100 km across the regions of the Slovak Republic (e.g. special syrups, flour, pasta or strudel). For the transport of products from local producers, they do not use their own transport or only in rare cases (for a small part of the products). It is a model using an intermediary (Paciarotti et al. 2022), including large distribution companies (e.g. Dmi TRADING SK s.r.o., CEVA, GTN s.r.o., Gastland s.r.o., Zdravé ovocie s.r.o. and etc). From a spatial point of view, the group of establishments represents the spatially extended relations between the

producer and the foodservice establishment - the consumption of local products is carried out outside the territory of the location/region (Renting et al. 2003). The advantage of this model is ensuring the necessary quantity and range of products, smoothness of deliveries throughout the year and provision of services related to logistics. In countries with developed LFS, the mentioned role is fulfilled by "local food centers". In the examined conditions, local food centers are replaced by widely operating companies (intermediaries), which ensure product promotion, orders (usually via a virtual platform), delivery of ordered products to restaurants but also counseling, lectures or new recipes.

*M4 - Model "farmer - restaurant in the countryside" (20 establishments)*

The 4th group of catering establishments are mainly located in the countryside. Their common characteristic is that they mostly buy from the producer in the immediate surroundings (median 11.7 km). They also make intensive use of farm shops and local markets. They do not buy from product processors at all, and they make limited use of an intermediary when purchasing. They use their own transport for the delivery of products. This group of SFSCs is based on face-to-face interaction between producers and foodservice establishments (Holloway, Kneafsey 2000; Pretty 1998) through the use of farmers' markets or farm shops. At the same time, it represents the SFSC group, which Enthoven, Van den Broeck (2021) included in the direct retail SFSC group, which assume production and sales at the same location. Thus, these are local food systems whose producers are usually located in rural areas near a larger town or city, aiming to increase their income by also operating as processors and retailers (Jarzębowski et al. 2020). This group includes foodservice establishments having "close" relations mainly with producers of meat and dairy products (agricultural cooperatives have repeatedly appeared in the group), which distribute products directly on the farm or through ambulatory sales (mobile stores). A distinctive feature of the producers is the distribution of products outside the wholesale market and the declaration of environmentally friendly animal/crop of plant origin, without the use of harmful products.

*M5 – Model "farmer - processor - restaurant" (13 establishments)*

The 5th group includes establishments located in both rural and urbanized areas (location does not play a significant role). A common characteristic of the group is that all facilities deliver from a processor of local/regional products. At the same time, they are not food producers themselves and do not buy from an intermediary and do not use yard sales and self-harvest. They only rarely use their own transport for shopping.

## CONCLUSIONS

Conducted survey of Slovak foodservice establishments showed that 44% of establishments are involved in SFSC. Foodservice establishments involved in SFSC use various forms (farm sales, farm stores, local markets, self-collection, box sales, etc.) for their supply as well as combinations of the mentioned forms. It is the combination of different raw material procurement strategies for food preparation that points at the diversity of the range of raw materials that restaurants require from producers and the need for communication with different food suppliers. From the comparison of the groups of foodservice establishments involved and not involved in the SFSC, we found several differences related to logistics. Establishments involved in SFSC tend to have more flexible scheduled ordering processes, favour long-term sourcing strategies and have better established supplier relationships compared to non SFSC ones. The ability to ensure supply by own transport is also significantly higher for establishments involved in the SFSC than for establishments that are not involved in the SFSC. On the one hand, this points to their flexibility in supply, on the other hand, it indicates the absence of more complex developed distribution systems (LFS). We used cluster analysis to identify the organizational models of foodservice establishments´ involvement in SFSC.

The result of our research is distinguishing different groups of foodservice establishments involved in SFSC between 5 organizational models (M1 "direct sale farmer - restaurant in the city", M2 "direct sale farmer/processor - restaurant in the countryside", M3 "farmer - intermediary - restaurant in the city", M4 " farmer - restaurant in the countryside", M5 "farmer - processor - restaurant"), which differ mainly in the location of the establishment, the method of involvement in the SFSC, the distance and type of supplier and transport. Models M1 and M4 are based on a close "face-to-face" relationship between producer and restaurant (consumer), as reported by Enthoven, Van den Broeck (2021), Holloway, Kneafsey (2000) and Pretty (1998) with differences in the location of the foodservice establishment and in preferred logistics. M2 represents a model in which the farmer and the processor have a cumulative position or is an intermediate link in the distribution chain between the farmer and the restaurant in the countryside. This group was identified by Jarzębowski et al. (2020) within LFS. Models M3 and M5 also represent SFSCs with an intermediate link in the distribution, which is a processor or intermediary. In both models, restaurants rely on the distribution transport secured by an intermediary. In the M3 model, larger distribution companies also appear as intermediaries, which, despite being linked to conventional supply chains, obtain food locally and declare their commitment to local farmers to sell their products (Enthoven, Van den Broeck 2021; Whatmore, Thorne 1997). They can be considered as a part of the SFSC for the mentioned reason. We believe that the services of a local food center could be an effective support for the building of more complex local food systems with the participation of catering facilities, which in Slovak

conditions, are created only gradually and without greater territorial coordination. Paciarotti, Torregiani (2021) state that these services can be provided without an intermediary (designed according to the characteristics of a cloud computing system) through an online platform. So the actors interact directly within the system - customers have the opportunity to choose the farmers they will buy from and communicate directly with them. The service provider of the local food center will ensure communication and logistics in the LFS. Such a solution brings positive effects to private entrepreneurs (farmers and restaurants) in the form of simplification of communication and logistics as well as to local self-government in the form of valuation of territorial assets, sustainable development of the territory and support for the development of tourism.

The limitations of this research are twofold. The first is the underrepresentation of the Bratislava and Košice regions in the sample, which are major urban centres, potentially containing niche forms of SFSC organisational models. The methodology used to categorize organisational models is also a limitation, as it does not allow for a detailed assessment of the complex and diverse relationships between food service establishments and their suppliers at an individual level.

It is important to note that external factors such as crises in the economic, social, health, environmental, or political spheres can also influence the functionality and reliability of the MPS (Matlovič, Malovičová 2024). These can be the cause of various failures in the MPS such as supply chain disruptions, lack of resources, labour or food price fluctuations. Addressing the problems caused by crises requires the adoption of specific strategies to increase the resilience of the MPS and flexible adaptation of all links of the SFSC i.e. farmers, foodservice establishments as well as consumers. The experience of foodservice establishments gained by overcoming obstacles during crises may influence their motivation to engage in SFSCs in the future Examining their impact and choosing catering establishments' strategies to deal with the impacts of crises and poly-crises is a topic for further research in this area. We also see the potential for further research focused on the involvement of catering establishments in the SFSC in a more detailed examination of consumer behaviour, especially preferences for consuming food prepared with locally sourced ingredients. Local food can be an important attraction factor in gastronomic tourism. Exploring the motivations of visitors to foodservice establishments that are part of the MPS could also be of interest in the Slovak conditions.

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# CHALLENGES AND OPPORTUNITIES FOR ADVANCING ELECTRIC CARSHARING IN CENTRAL EUROPE

## The Role of Infrastructure, Policy and Consumer Behavior in the Adoption of E-carsharing in Central Europe

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**Abstract**
Electric carsharing (e-carsharing) systems hold significant potential for promoting sustainable urban mobility in Central Europe, in this study particularly examined in Hungary, Slovakia, and Romania. Through a comparative analysis of carsharing models, charging infrastructure, and regulatory frameworks, this paper identifies key factors influencing the adoption of e-carsharing. The results demonstrate that while e-carsharing can substantially reduce carbon emissions and alleviate traffic congestion, its widespread implementation faces obstacles such as insufficient charging networks, limited governmental support, and consumer preferences for car ownership. In Central Europe, especially in the countries under examination, car ownership still holds great significance, which hinders the spread of e-carsharing services. Therefore, it is particularly important for e-carsharing services to be competitive, making government incentives necessary. Technological innovations like AI-based fleet management and Vehicle-to-Grid (V2G) systems are essential for improving operational efficiency and sustainability. Policy recommendations emphasize the need for robust government incentives, coherent energy policies, and targeted financial mechanisms to foster the growth and long-term viability of e-carsharing across the region.

**Key words**
Sharing economy, electromobility, carsharing, CEE, V2G, AI, Decision-makers

## INTRODUCTION

Electric carsharing (e-carsharing) is becoming increasingly prominent in the evolution of sustainable transportation, combining the environmental advantages of electric vehicles with the flexibility inherent in shared mobility services. (Icaza et al., 2023; Rizopoulos et al., 2022; Sadhu et al., 2022; Venkatesh and Raslavičius, 2024; Yassine et al., 2024). E-carsharing allows users to access electric vehicles for short periods, avoiding the long-term financial commitments typically linked to vehicle ownership. (Amamra and Marco, 2019; Leal Filho et al., 2021; Ritter and Schanz, 2021). This model proves especially advantageous in urban environments, where traffic congestion, air pollution, and limited parking space pose daily challenges (Alanazi, 2023; Hassler et al., 2021; Manso-Burgos et al., 2021; Ravi and Aziz, 2022; Venkatesh and Raslavičius, 2024).

The aim of this study is to provide a detailed overview of the carsharing networks in Budapest, Bucharest, and Bratislava, with a particular focus on electric carsharing systems. The various infrastructural and regulatory challenges in these cities have a significant impact on the adoption and sustainability of e-carsharing services. Additionally, the study seeks to analyze the technological advancements in electric carsharing and their effects on user experience.

E-carsharing models are inherently tied to the rapid expansion of the sharing economy, with a primary focus on environmental sustainability (Galan and Zuñiga-Vicente, 2023). Leveraging innovative opportunities, providers can adopt emerging digital business models and essential sustainability tools (Briguglio and Formosa, 2023; Malakhatka et al., 2024; Ritter and Schanz, 2021; Y. Wang et al., 2024; Yassine et al., 2024). In recent years, a growing number of consumers and urban dwellers have embraced shared economy models that prioritize access over ownership (Han and Sun, 2024; Yang et al., 2024). Carsharing is particularly appealing to users who drive less frequently and wish to avoid the costs and responsibilities of vehicle ownership. Integrating electric vehicles into carsharing systems provides a pathway to decarbonize the transportation sector and enhance the efficiency of the whole transport system (Huang et al., 2020; Sarsia et al., 2023; Shaban et al., 2023; Venkatesan et al., 2024; Zhang et al., 2024a). E-carsharing systems offer major environmental benefits by reducing carbon emissions and local air pollution, contributing to sustainable urban transportation (Christensen et al., 2021; Luo et al., 2023; Sarsia et al., 2023). Moreover, e-carsharing fosters greater acceptance of electric vehicles by allowing users to experience the technology without the need for long-term commitment (Bohdanowicz et al., 2022; Hu and Han, 2023; Stanchev et al., 2023; Tiwari and Farag, 2022).

The integration of electric vehicles into the grid (Christensen et al., 2021; Huang et al., 2020; Neaimeh and Andersen, 2020; Pietracho et al., 2022; "Resilience

Enhancement of Urban Energy Systems via Coordinated Vehicle-to-grid Control Strategies," 2023) alongside load management, requires advancements in energy distribution systems, particularly for expanding urban charging networks (Ahmed et al., 2023; Lewicki et al., 2024; Zenhom et al., 2023; Zhang et al., 2024a). Integrating electric vehicles into the grid serves as a strategy to mitigate the extremities, the peaks and lows, of grid usage (Letha et al., 2023; Malya et al., 2021; Salehimehr et al., 2024; Srivastava et al., 2023).

The distinct economic, infrastructural, and social conditions of Central Europe profoundly influence the development and expansion of e-carsharing models (Y. Wang et al., 2024). The availability of electric vehicles, government incentives, the development of charging infrastructure, beside public awareness of environmental and financial benefits collectively shape the success of e-carsharing services (Bridi et al., 2024; Jaman et al., 2023). In this region, the adoption of electric vehicles may be impeded by income disparities, shortcomings in charging infrastructure, and insufficient user awareness regarding the advantages of electric mobility (Ritter and Schanz, 2021). Simultaneously, there is substantial growth potential for electric carsharing in Central Europe, particularly in metropolitan regions where transportation challenges and sustainability demands are more acute (Ma and Fang, 2022; Pan et al., 2023; Y. Wang et al., 2024). The expansion of electric carsharing and charging infrastructure presents new opportunities for building energy management systems (Brhane et al., 2024; Hossain et al., 2023; Jiang et al., 2023; Lewicki et al., 2024; Pedram et al., 2023). Electric vehicle charge control can not only contribute to building energy management systems but it also assists in balancing peak loads (Bhundar et al., 2023; Liu et al., 2023; Lu et al., 2023; Toniato et al., 2021). The sustainability of electric carsharing fundamentally depends on the efficiency of demand-side energy management (Bogdanova et al., 2023; Chen et al., 2024; Dorji et al., 2023; Mahani et al., 2023). As smart grids advance, the application of effective energy management techniques is becoming crucial (Venkatesan et al., 2024; Bakare et al., 2023; Muqbel et al., 2024; Esfandi et al., 2024; Kusznier, 2023; Ma et al., 2021; Mazhar et al., 2023).

Electric carsharing systems are progressively incorporating advanced technologies, such as mobile applications and real-time data management, to enhance user experience and optimize service efficiency (Briguglio and Formosa, 2023; Malakhatka et al., 2024; Y. Wang et al., 2024). Optimizing user experience is essential for fostering the widespread adoption of e-carsharing, as intuitive platforms and streamlined rental processes contribute to positive user experiences and foster long-term loyalty (Ritter and Schanz, 2021; Yang et al., 2024).

The regulatory framework also plays a pivotal role in shaping the development of e-carsharing markets, as government incentives and support mechanisms can substantially influence the expansion of charging infrastructure and the enhancement of user awareness (Jaman et al., 2023; Rego et al., 2023; Yassine et al., 2024).

## Challenges of Electric Carsharing Systems

Electric carsharing offers benefits in both environmental sustainability and economic efficiency, yet it faces several critical challenges that may impede its broader adoption (Huang et al., 2020). On the other hand, there are a lot of challenges that service providers and users may face in the Central European context (Ghatikar and Alam, 2023). The following section enquires into these challenges.

### Challenges in the Adoption of Electric Carsharing Systems

Despite the substantial environmental and economic benefits associated with e-carsharing, several challenges persist that may impede its widespread adoption, particularly within the Central European region (Bohdanowicz et al., 2022; Coban et al., 2022). A primary challenge lies in the construction and expansion of the charging infrastructure necessary for electric vehicle operation (Alanazi, 2023; Holly et al., 2020; Horváth et al., 2023). Efficient operation of e-carsharing services requires not only a sufficient number and the strategic placement of charging stations but also a continuous supply of clean energy to minimize the environmental impact of charging (Alanazi, 2023; "High Power Density EV Integrated Fast Battery Chargers Based on the General Torque Cancelation Law for Three-Phase Motors," 2024; Pan et al., 2023; Reddy et al., 2023).

Inadequacies in charging infrastructure not only diminish the user experience but also escalate operational costs (Shipman et al., 2019). When users fail to park vehicles at designated charging points, providers may require two employees to relocate the vehicle: one to drive it to the charging station and another to transport the first employee back. This situation can result in substantial labor costs and operational inefficiencies for providers. Thus, it is in the long-term interest of service providers to establish extended charging points in urban areas, where additional services such as cleaning and vehicle inspections can be performed concurrently, optimizing operations (Dalyac et al., 2021).

### Comparative Advantages of e-Carsharing Over Taxi Services

E-carsharing services provide numerous advantages over conventional taxi services, particularly with regard to flexibility and operational efficiency. Whereas taxi services entail a separate booking for each trip, e-carsharing enables users to drive a pre-booked vehicle at their convenience and pace, granting them more autonomy. Additionally, taxis frequently operate without passengers while waiting for new bookings, resulting in unnecessary fuel consumption and contributing to increased traffic congestion. In contrast, e-carsharing vehicles are utilized solely when required, facilitating more efficient energy use, particularly when vehicles

are stationed at charging points during periods of inactivity. This inherent flexibility and cost-efficiency render e-carsharing services especially appealing for urban transportation solutions.

### Regulatory Challenges and Energy Efficiency in e-Carsharing Systems

Regulatory frameworks are pivotal in advancing the sustainability and widespread adoption of electric carsharing systems. To ensure the broad accessibility of e-carsharing, it is imperative to implement a supportive regulatory framework that promotes the integration of renewable energy sources and facilitates the development of essential infrastructure (Sousa and Costa, 2022; Sousa-Dias et al., 2024; Yassine et al., 2024).

Government interventions, including tax incentives, financial subsidies, and regulatory measures supporting the establishment of electric charging infrastructure, are critical in fostering the proliferation of electric vehicles. Conversely, the lack of appropriate regulatory framework can impede the development and the expansion of charging infrastructure, consequently restricting the growth of e-carsharing services within urban areas (Annamraju and Nandiraju, 2019a; Mulder and Klein, 2024; Zhou et al., 2023).

It is crucial for governments and local authorities to formulate coherent and comprehensive energy policies that facilitate the integration of renewable energy sources into the electric charging infrastructure. This approach not only supports the provision of clean energy but also contributes to the reduction of urban air pollution (Ahmed et al., 2024; Alfaverh et al., 2023). The deployment of hybrid energy storage systems is equally critical, as these systems enhance energy efficiency, alleviate grid load, and minimize environmental impact (Hassan et al., 2024; Tahir et al., 2024).

Beyond adequate government support, collaboration between public utilities and private enterprises is equally imperative for the development of effective regulatory frameworks. This is the only way to ensure that e-carsharing systems develop sustainably and present an attractive alternative to traditional car usage for users (Demirci et al., 2024; Salkuti, 2023; Xu et al., 2022).

To ensure the future development and the widespread adoption of electric vehicles, regulatory frameworks must remain flexible and adaptable, accommodating technological advancements and evolving user needs. Therefore, governments must prioritize the creation of support and incentive systems to ensure that sustainability-promoting e-carsharing truly achieves its goals (Adeyinka et al., 2024; Alpízar-Castillo et al., 2022; Berkes and Keshav, 2024; Li et al., 2022; Payakkamas et al., 2023).

## Territorial Analysis of Carsharing Services in Central Europe

Electric vehicles (EVs) produce zero local emissions, given that they operate without the combustion of fossil fuels (Xu et al., 2024). Consequently, e-carsharing systems can contribute to the reduction of urban air pollution, a critical factor linked to serious health issues in metropolitan areas (Yang et al., 2024). This study aims to provide an in-depth examination of carsharing services across three Central European countries—Hungary, Romania, and Slovakia—focusing specifically on mapping their current state and sustainability dimensions. The analysis seeks to present a comprehensive overview of the current state of carsharing systems in the region, while identifying future development trajectories and potential growth opportunities (Briguglio and Formosa, 2023; Horváth et al., 2023; Y. Wang et al., 2024). Sustainability initiatives, alongside technological and infrastructural innovations, play a crucial role, as these factors critically shape the future development of carsharing. The analysis accounts for local consumer habits and attitudes influencing demand for carsharing services, alongside region-specific challenges and opportunities within the framework of sustainable mobility (Briguglio and Formosa, 2023; Horváth et al., 2023).


**Fig. 1:** The number of shared cars per 100,000 residents

*Source: own editing according to ("Finally Here: MOL Limo Strengthens Fleet with Suzuki," 2024; "MOL Limo Car-Sharing Service," 2024; "MOL Limo Expands Fleet with Mercedes Vehicles," 2018)*

There are significant differences in the development of carsharing markets between Western European and Central European countries. In Germany, where the carsharing market is the largest, there are 51 cars per 100,000 residents, in France there are 20 cars per 100,000 residents, and in the Netherlands, there are 40 shared cars per 100,000 residents. In contrast, Hungary has 14 cars, Romania has 1 car, and Slovakia has no cars available per 100,000 inhabitants ("INVERS GmbH (2024): INVERS Mobility Barometer. European Car Sharing," 2024; "The European Alternative Fuels Observatory provides comprehensive statistical data on all European Union member states," 2024). Besides the number of cars per 100,000 inhabitants, the countries involved in the current study are also lagging behind in other respects, as while there are car-sharing services available in several cities in Western European countries, in the countries we examined, such services can be found exclusively in the capital cities. Therefore, since car-sharing services can be utilized in urban transportation, this research will take a closer look at the car-sharing services in the capitals of the three examined countries. The number of shared cars per 100,000 residents is shown in Figure 1. It can be stated that among the three examined cities, Budapest stands out, as there are nearly 85 cars per 100,000 people, while in Bucharest, there are 11 cars, and in Bratislava, significantly fewer, with not a single car available per 100,000 residents. In Bratislava, there is only one micro-enterprise, which has a limited fleet, indicating that the opportunities for e-carsharing in Bratislava are underutilized. It cannot provide a viable alternative for urban transport unless there is an emergence of more providers and a larger fleet. At the same time, even in the case of Budapest, 85 shared cars per 100,000 residents prove to be quite inadequate. Overall, the figures show that all three examined cities require significant development in e-carsharing, which necessitates intervention from decision-makers and support for potential providers.

### Comprehensive Overview of Budapest's Transportation Situation

Budapest, the capital of Hungary, with a population exceeding 1.75 million, has experienced substantial transformations in its public transportation system in recent years. The city's transportation network is traditionally centered around buses, trams, trolleybuses, and metro systems; however, carsharing services have been gaining increasing prominence. Sustainability considerations are obtaining priority, paralleling the increased adoption of electric vehicles and the integration of multimodal transportation options. Carsharing services, including GreenGo, MOL Limo, and Wigo, have been attaining firm foothold among the city's residents.

### Growth of Carsharing Services in Budapest

In recent years, carsharing services have experienced significant growth in Budapest, in line with the city's commitment to promoting sustainable mobility. GreenGo, a carsharing provider exclusively offering electric vehicles, has steadily expanded its fleet since its launch in 2016 and currently it operates 470 fully electric vehicles across the city. In contrast, MOL Limo runs a mixed fleet, comprising both internal combustion engine (ICE) vehicles and electric cars. MOL Limo currently operates a fleet of 450 vehicles, 30% of which are electric, with the proportion of electric vehicles expected to increase in the coming years ("Finally Here: MOL Limo Strengthens Fleet with Suzuki," 2024; "MOL Limo Car-Sharing Service," 2024; "MOL Limo Expands Fleet with Mercedes Vehicles," 2018). Wigo, the most recent provider, manages a fleet of 500 vehicles, consisting of both internal combustion engine (ICE) and battery electric vehicles (BEV). A notable advantage of Wigo is its young fleet, with an average vehicle age of 18 months ("Introduction to Wigo," 2024).

### The Expansion of Electric Vehicle Charging Networks and Infrastructure

The increasing adoption of electric vehicles poses new challenges for Budapest's urban infrastructure, particularly concerning the availability and density of charging stations. Many countries in the Central European region face comparable challenges, where regulatory gaps and underdeveloped infrastructure present significant obstacles (Horváth et al., 2023). According to EAFO data, in 2023 there were more than 731 public electric charging points in Budapest. The capacity of the charging infrastructure has experienced substantial growth in recent years, with charging stations providing an average power output of 22-50 kW. Nationally, the growth rate of charging infrastructure expanded by 15% between 2022 and 2023 ("The European Alternative Fuels Observatory provides comprehensive statistical data on all European Union member states," 2024), A total of 3,960 charging points were installed by Q3 2024, 21% of which are fast chargers. The most significant progress has been observed in Budapest ("MEKH Charging Points," 2024), particularly in the downtown areas where vehicle usage is the highest. In the future, the number of charging points is projected to continue increasing, with expanded coverage anticipated in suburban areas.

### The Growth of Multimodal Transportation Options in Budapest

In Budapest, in addition to vehicle-sharing services, electric scooters and bicycles are assuming an increasingly significant role in urban transportation. The incorporation of electric scooters into urban transportation offers several advantages, particularly in addressing short-distance and rapid transit requirements. Electric scooters operate with zero emissions, thereby contributing to the enhancement of urban air quality (Pan et al., 2023). Their compact and easily

maneuverable design makes them particularly advantageous in congested urban areas and regions facing parking challenges. Moreover, electric scooters contribute to alleviating traffic congestion, offering a sustainable alternative to car usage and thus enhancing both the efficiency and environmental sustainability of urban mobility (Venkatesh and Raslavičius, 2024).

Budapest is home to two prominent electric scooter-sharing providers. Lime, one of the largest operators, currently offers over 500 electric scooters, primarily in the central urban areas. The Lime service provides a fast and efficient transportation solution, particularly advantageous in densely populated city regions, where parking and mobility present significant challenges ("Introduction to Lime," 2024).

Tier is another major player in Budapest's electric scooter market. The company puts great emphasis on sustainability, with its scooters operating at zero emissions, thereby contributing to the reduction of environmental impact. The provider's electric scooters are primarily available in the city center, where they offer an effective alternative for short-distance transportation, addressing the growing demand for energy-efficient mobility solutions (Chou et al., 2023; "Introduction to Tier," 2024). However, in 2024, the Blinkee scooter-sharing service ceased operations in Budapest, leading to a marked reduction in the availability of electric scooters across the city ("Blinkee megszűnése," 2024). In the bicycle-sharing domain, MOL Bubi is a leading service provider. Since its launch in 2014, its fleet has steadily grown and now consists of 2,460 bicycles available for rent at 211 stations throughout the city ("Introduction to MOL Bubi," 2024; "MOL Bubi: Budapest's Greenest Public Transport Solution," 2024). In recent years, MOL Bubi has implemented significant upgrades, focused on modernizing its fleet and expanding its services. Future plans include the introduction of electric bicycles, which are anticipated to further increase the user base and enhance the system's attractiveness.

### Sustainability and Strategic Future Directions In Budapest's Transportation Policy

Sustainability and environmental protection are anticipated to assume an increasingly fundamentalrole in Budapest's transportation policy moving forward at present. However, low-emission zones (LEZ) have not yet been implemented, nor have congestion charges been introduced, despite both measures being integral components of the city's long-term plans. The primary objective of these initiatives is to contribute to the reduction of carbon dioxide emissions and mitigate transportation-related challenges. Promoting vehicle-sharing services and reassessing parking regulations could also be pivotal to advancing sustainable urban mobility, potentially enhancing the appeal of public transportation while simultaneously reducing road congestion.

All three companies reported negative financial outcomes for the year 2023, albeit to varying extents. MOL Limitless Mobility Kft. experienced a comparatively smaller financial deficit, whereas WAMO and GreenGo Car Europe Zrt. faced more serious challenges, largely attributed to geopolitical and market dynamics. These outcomes underscore the precarious and uncertain economic landscape surrounding services focused on sustainable urban mobility ("Green Car Europe Zrt. Audited Annual Report," 2023; "Mol Limitless Mobility Kft. Company Data," 2023; "Wigo (Wallis Autómegosztó Zrt.) Annual Report," 2023).

In terms of workforce size, WAMO is the largest employer among the three, whereas GreenGo Car Europe Zrt. and MOL Limitless Mobility Kft. operate with comparatively smaller labor forces. This distribution of labor indicates that the various car-sharing providers adopt different approaches to organizing and developing their operations ("Green Car Europe Zrt. Audited Annual Report," 2023; "Mol Limitless Mobility Kft. Company Data," 2023; "Wigo (Wallis Autómegosztó Zrt.) Annual Report," 2023).

All three companies are confronted with challenges, including elevated costs, geopolitical risks, and market volatility. However, they strive to maintain and expand their activities through continuous improvements, aligning well with Budapest's transportation policy objectives. Vehicle-sharing services can not only render urban transportation more sustainable but also contribute to the enhancement of transportation infrastructure and urban quality of life. Moving forward, the synergy between transportation policy advancements and electric vehicle-sharing services is poised to play a central role in realizing Budapest's sustainability objectives.

### The Evolution and Future Trajectory of Slovakia's Car-Sharing Market

In recent years, Slovakia's car-sharing market, particularly in Bratislava, has experienced significant transformation, which earlier studies did not foresee. The initially optimistic scenarios for the proliferation of car-sharing and its anticipated impacts on urban transportation. However, the COVID-19 pandemic unexpectedly disrupted these projections, leading to significant economic challenges for the sector. At present, only one microenterprise, ShareCar, operates in Bratislava's car-sharing market, offering a mere four electric vehicles ("Introduction to Sharecar.sk," 2024). This limited capacity is insufficient to address the city's mobility needs and clearly illustrates that the considerable potential within the market remains untapped (Roblek et al., 2021; Stahl, 2021). In Slovakia, the charging infrastructure for electric vehicles (EVs) is undergoing continuous expansion; however, the distribution of charging points remains insufficient for widespread adoption. According to EAFO data, as of Q3 2024, there are a total of 2,699 charging points in the country, with 31% being fast chargers. Given the city's automotive traffic, the number of charging stations in Bratislava calls for further development,

rendering the expansion of charging infrastructure in the city critically important for advancing sustainable transportation. Increasing and optimizing the available charging points is essential (Dalyac et al., 2021), ensuring that users can easily access charging options, thereby supporting the proliferation of electric vehicles and the development of car-sharing services ("EAFO Number of Charging Points in Slovakia," 2024; Shipman et al., 2019). According to Statista, the annual growth rate (CAGR) of the car-sharing market in Slovakia is 11.82%, and revenues are expected to reach €12 million by 2028, while the number of users could approach 92,000. These figures indicate that the opportunities within the sector are immense; nevertheless, the current situation does not reflect this potential ("Slovakia Car-Sharing Report," 2024). To promote sustainable transportation, it is essential to develop the transport infrastructure alongside the implementation of appropriate car-sharing services and the establishment of electric charging stations, which would enable the wider use of zero-emission vehicles (Roblek et al., 2021; Stahl, 2021). According to a research by the Wuppertal Institute, the role of car-sharing becomes crucial for improving the sustainability of urban transportation, and optimizing existing models is necessary to enhance the efficiency of urban mobility (Rudolph et al., 2021).

The current market environment indicates an urgent need for governmental intervention, with the involvement of financially robust companies potentially representing a strategic approach to revitalizing the sector through concerted efforts. Car-sharing in Bratislava remains in its early stages, but if the necessary infrastructure and services expand, future growth could emerge as a realistic possibility.

### The Current State and Future Prospects of Romania's Car-Sharing Market

Based on Statista data for 2024, Romania's car-sharing market is projected to witness dynamic growth, with anticipated revenues of €9.9 million by 2028 and an estimated user base nearing 77,000. This trend highlights that car-sharing serves not only as an alternative mobility solution but also as a fundamental pillar of sustainable urban transportation ("Romania Car-Sharing Report 2024," n.d.).

EAFO data for Q3 2024 indicates that Romania hosts a total of 3,922 electric vehicle charging points, with 36% classified as fast chargers ("EAFO Number of Charging Points in Romania," 2024). The number of charging points in the country is continuously increasing, which is a positive sign for sustainable transportation. However, the proportion of fast chargers indicates that developing the charging infrastructure is particularly important for ensuring that users can conveniently and quickly access charging options. In Bucharest, the number of charging stations is still considered low in relation to the city's automotive traffic, which hinders the widespread use of electric vehicles and the proliferation of car-sharing services.

Enhancing the city's charging infrastructure and optimizing the distribution of charging points are critical to advancing sustainable transportation (Dalyac et al., 2021; Mulder and Klein, 2024). These steps could contribute to a greater adoption of zero-emission vehicles and enhance the user experience in urban transportation. Future challenges include changes in consumer behavior, increasing market competition, and establishing appropriate legal frameworks to support car-sharing initiatives (Alanazi, 2023). The integration of urban transportation policies, increasing social acceptance, and the introduction of technological innovations are essential for the Romanian car-sharing sector to truly harness its potential and contribute to the development of sustainable urban mobility (Sarsia et al., 2023; Zhang et al., 2024b).

The situation of car-sharing services in Bucharest has undergone significant transformation in recent years. The initially launched GetPony and Spark services were suspended due to the COVID-19 pandemic and funding difficulties, leaving Citylink as the sole representative of the car-sharing segment in the market, with approximately 250 passenger cars ("Case study – Car Sharing," 2024). Citylink focuses on the use of hybrids, thereby prioritizing sustainability in urban transportation. In addition to car-sharing, Citylink also offers bicycle solutions, having deployed a total of 350 bicycles on the streets of Bucharest ("350 Citylink bicycles on the streets of Bucharest," 2024). The service aims to promote sustainable transportation while reducing urban traffic and air pollution. Users can easily rent cars and bicycles through a mobile application, allowing them to access transportation options conveniently and adapt flexibly to their needs.

The current landscape presents both challenges and opportunities, as Bucharest's car-sharing market remains in an early stage of development. Citylink's operations and the services it offers contribute to the sustainability of urban mobility, but the emergence of additional market players is also necessary to make car-sharing services more widely available and attractive to users. When developing future car-sharing models, it is imperative to account for the increasing demand for sustainable transportation solutions.

## Key Challenges Facing e-Carsharing Adoption in the Central European Market

Electric carsharing presents potentials within the Central European transportation market, as examined in Hungary, Slovakia, and Romania. Recent research underlines both the advantages and challenges inherent in e-carsharing models. The primary aim of the conclusions and recommendations is to assist policymakers, service providers, and users in the effective development and widespread adoption of e-carsharing systems (Alanazi, 2023; Almutairi et al., 2023; Borghetti et al., 2023; Icaza-Alvarez et al., 2023).

The expansion of e-carsharing systems across Central Europe, particularly in Hungary, Slovakia, and Romania, presents substantial opportunities for the development of sustainable transportation infrastructure. E-carsharing presents substantial economic benefits for both users and service providers (Demirci et al., 2023), such as the purchase price, depreciation, insurance premiums, fuel expenses, and maintenance or repair costs (Shipman et al., 2019). Through e-carsharing services, users pay solely when they require a vehicle, leading to significant cost savings for individuals who utilize cars infrequently (Al-Ghaili et al., 2022; Hassan et al., 2024).

The advantages of such systems encompass reducing air pollution and alleviating traffic congestion, while simultaneously enhancing the efficiency of urban mobility (Jiang et al., 2023; Venkatesh and Raslavičius, 2024; Yassine et al., 2024). The lower operating costs of electric vehicles (EVs)—including charging and maintenance expenses—also enhance the economic competitiveness of e-carsharing compared to internal combustion engine (ICE) vehicles (Alanazi, 2023; Y. Wang et al., 2024). Nevertheless, the establishment and maintenance of adequate charging infrastructure, particularly in urban and suburban areas, represent a fundamental challenge to the widespread adoption and long-term viability of e-carsharing systems (Horváth et al., 2023; Shipman et al., 2019; Wu et al., 2024).

Consumer behavior and attitudes are pivotal in shaping the acceptance of e-carsharing. Proper information and education for consumers are essential for making car-sharing a part of their daily lives. Understanding the heterogeneous demand for electric vehicles (EVs) and the diverse user preferences is also a critical factor in the development of car-sharing services (Briguglio and Formosa, 2023; Dorji et al., 2023; Yang et al., 2024). User behavior, such as charging habits and car usage preferences, fundamentally influences the efficiency and sustainability of car-sharing systems (Esfandi et al., 2024; Zhang et al., 2024a).

The integration of electric vehicles into smart grids enhances both energy efficiency and grid stability, particularly through Vehicle-to-Grid (V2G) technologies, allowing electric vehicles to act as energy sources (Darani et al., 2021; Mulder and Klein, 2024; Sora et al., 2024). The development of charging infrastructure should also consider energy storage solutions and smart charging technologies, which contribute to reducing grid load (Huang et al., 2020; Neaimeh and Andersen, 2020). Divergent regulatory environments, high initial investment costs, and shifts in consumer behavior may also present significant obstacles to the widespread adoption of e-carsharing (Giannelos et al., 2024; Jafari Kaleybar et al., 2024). Understanding consumer habits is fundamental to the success of electric car-sharing systems and to the conscious transition of drivers to the everyday use of car-sharing. It is particularly important to encourage car users towards shared vehicles while striving to minimize the temptation for public transport

users to switch to car-sharing (Dorji et al., 2023; Yang et al., 2024). Consumers who decide between public transport and car usage may be particularly sensitive to promotional offers and educational programs that can steer them toward e-carsharing. Although the development of infrastructure requires high initial costs, smart grids and appropriate charging systems play a key role in the sustainable development of car-sharing.

The benefits of car-sharing include not only economic advantages but also environmental gains, as electric vehicles help decarbonize the transportation system (Alanazi et al., 2024; Boudmen et al., 2024; Sultan et al., 2022). At the same time, the transition to shared cars does not come with benefits in every regard and aspect. It should be noted that the use of shared cars has a spatial limitation, as the services usually only extend within the defined boundaries of a city. Therefore, for intercity travel, using public transportation is essential for traveling without car ownership, which is not necessarily a more environmentally friendly mode of travel either (Pařil and Viturka, 2020).

### User Habits and Attitudes

Consumer attitudes and behaviors are fundamental in the adoption and proliferation of electric carsharing systems. The increasing popularity of e-carsharing is closely linked to rising environmental consciousness, which concurrently drives demand for electric vehicles (Anastasiadou and Gavanas, 2022; Pan et al., 2023; Shipman et al., 2019; Wu et al., 2024). Predominantly, consumers continue to favor personal vehicle ownership, perceiving it as a symbol of autonomy and convenience.

The COVID-19 Pandemic changed numerous aspects of our lives – and urban mobility was no exception. Residents had to completely change their lifestyle and travel habits, some of which changes persisted even after the pandemic. For instance, the 15-minute city concept was created, the essence of which is that locations for everyday tasks should be accessible within 15 minutes – such as the workplace, shopping centers, and public spaces. The concept of the 15-minute city also helps to uplift the underdeveloped areas of the city (Mocák et al., 2022). One important factor in this could be e-carsharing services, which enhance urban mobility.

E-carsharing presents substantial economic benefits for both users and service providers (Demirci et al., 2023), such as the purchase price, depreciation, insurance premiums, fuel expenses, and maintenance or repair costs (Shipman et al., 2019). Through e-carsharing services, users pay solely when they require a vehicle, leading to significant cost savings for individuals who utilize cars infrequently (Al-Ghaili et al., 2022; Hassan et al., 2024).

For service providers, the lower maintenance costs of electric vehicles, coupled with reduced fuel expenses, provide additional economic advantages. Electric

vehicles possess fewer mechanical components compared to traditional internal combustion engine (ICE) vehicles, thereby reducing the likelihood of breakdowns and minimizing the need for repairs (Saha et al., 2022). Moreover, the charging costs of electric vehicles are generally lower than those associated with traditional fuels, particularly when renewable energy sources are used (Demirci et al., 2024; Jafari Kaleybar et al., 2024).

Enhancing consumer awareness and effectively demonstrating the benefits of e-carsharing are critical to its successful adoption. This requires the provision of reliable and easily accessible services, with a strong emphasis on optimizing user experience (Han and Sun, 2024; Ma and Fang, 2022; Yang et al., 2024). Vehicle availability and the simplicity of booking processes are fundamental to the proliferation of e-carsharing, as consumers seek convenient access to these services (Adnan et al., 2023; Chamberlain and Majeed, 2022; Luo et al., 2023).

Moreover, the flexible utilization of e-carsharing systems can incentivize consumers to rent vehicles outside peak periods, thereby alleviating urban traffic congestion. Dynamic pricing models and optimized vehicle utilization can not only reduce costs but also help mitigate the strain on transportation infrastructure (Singh et al., 2022; Venkatesh and Raslavičius, 2024; Wang and Zhou, 2023; Yao et al., 2023).

The successful implementation of future urban mobility solutions necessitates a thorough understanding of consumer habits and attitudes, as these factors critically influence the sustainability and diffusion of e-carsharing systems (Horváth et al., 2023; Jakimowicz, 2022). Electric carsharing is not only suitable for meeting individual mobility needs but also contributes to the transformation of urban transportation, which is essential for a sustainable future.

### Flexible Tariffs and the Opportunities of Vehicle-To-Grid (V2G) Technology

The e-carsharing system presents a sustainable transportation alternative while simultaneously encountering emerging challenges and opportunities. To maintain system efficiency and sustainability, it is imperative for providers to implement flexible tariff structures that incentivize users to adopt conscious charging behaviors. Such tariff models enable providers to optimize fluctuations in electricity consumption by tailoring pricing mechanisms to vehicle charging patterns (Giordano et al., 2023; Gomes et al., 2020; Jiang et al., 2023; D. Li et al., 2023). For instance, strategic scheduling of charging periods—during off-peak times such as daytime or night-time—can mitigate grid load, thereby bolstering the stability of urban energy systems (Ahmed et al., 2023; Mądziel and Campisi, 2023; Sharida et al., 2024; Shipman et al., 2019; Venkatesan et al., 2024; Zahler et al., 2024).

The integration of Vehicle-to-Grid (V2G) technology represents a critical advancement for e-carsharing systems. This technology enables electric vehicles

to transition from mere energy consumers to dynamic energy sources, capable of feeding electricity back into the grid, thus alleviating grid strain during peak demand periods (Ali et al., 2024; Bernal-Sancho et al., 2023; Coban et al., 2022; Giannelos et al., 2024; Rao and Venkateshwarlu, 2024). Electric vehicles can reverse-feed energy into the grid, not only mitigating peak loads but also facilitating the seamless integration of renewable energy sources into urban energy infrastructures (Arandhakar et al., 2022; Mojumder et al., 2022; Srivastava et al., 2023).

### Introduction of Ai-Based Systems and Data-Driven Decision Making

Electric vehicle-sharing systems hold a pivotal role in advancing sustainable urban mobility. AI-driven systems are indispensable for optimizing energy consumption, facilitating real-time decision-making, and enhancing urban transportation efficiency. Leveraging these systems, the energy demands of vehicles can be precisely forecasted, enabling the optimization of charging cycles and more efficient utilization of urban infrastructure (Al-Chalabi and Banister, 2022; Benysek et al., 2022; Pai and Senjyu, 2022; Park et al., 2022; Strepparava et al., 2022). Smart charging systems provide solutions enabling vehicle charging during off-peak periods, thereby mitigating network overload and preventing unnecessary energy consumption spikes (El-Hendawi et al., 2022; Ghotge et al., 2022; Nepal et al., 2022).

AI-powered fleet management systems optimize vehicle operations, enable intelligent route planning, and precisely forecast charging demands (Lam et al., 2022; Ouramdane et al., 2022). Intelligent fleet management enhances vehicle availability, reduces operational costs, and improves energy efficiency (Galan and Zuñiga- Vicente, 2023; Goh et al., 2022; Saad et al., 2022). AI-driven fleet management enables real-time vehicle tracking, facilitating rapid responses to emergent maintenance needs and system faults (Czarnecka et al., 2022; Minhas et al., 2022; Vilathgamuwa et al., 2022).

The integration of AI technologies in urban mobility not only enhances energy efficiency but also bolsters the reliability of transportation networks. Intelligent urban systems enable dynamic management of energy consumption, optimal route planning, and more effective utilization of renewable energy sources, thereby contributing to the development of sustainable urban transportation (Bohdanowicz et al., 2022; Khan and Masood, 2022; Sousa and Costa, 2022).

### Recommendations for Decision-Makers

The effective advancement of electric carsharing systems in Central Europe necessitates strategic collaboration among policymakers, service providers, and end-users. This research aims to offer actionable recommendations for policymakers, recognizing their pivotal role in facilitating the widespread adoption of e-carsharing systems. While users may exhibit environmental consciousness,

without robust government support, the economic feasibility of adopting these services remains compromised. Public policy objectives must be designed to incentivize car users to transition to e-carsharing systems, thereby reducing conventional vehicle reliance and advancing sustainable mobility.

Ensuring the long-term sustainability of electric carsharing necessitates the efficient integration of decentralized renewable energy sources (Adnan et al., 2023; Jafari Kaleybar et al., 2024; Luo et al., 2023; Mulder and Klein, 2024; Tomczewski et al., 2023; Z. Wang et al., 2024). The effective integration of these energy sources facilitates the development of sustainable transportation models (Chamberlain and Majeed, 2022; Korõtko et al., 2023; Lazović and Đurišić, 2023; Yao et al., 2023). These systems are confronted with growing uncertainties, particularly concerning renewable energy sources (Annamraju and Nandiraju, 2019a, 2019b; Fu et al., 2022). These challenges encompass market fluctuations and rapid technological advancements (Ahmed et al., 2024; Michalski et al., 2024)

Proactively steering drivers towards carsharing is paramount, especially through the targeted development of infrastructure. The deployment of smart grids and energy-efficient charging infrastructures is crucial for ensuring the system's effective functionality, supported by targeted educational initiatives and promotional incentives (Demirci et al., 2023; Dorji et al., 2023; Icaza-Alvarez et al., 2023; Tomczewski et al., 2023).

Optimizing the energy consumption of electric vehicles during connection enhances the efficiency of both residential and commercial energy management. Additionally, it contributes to reducing the carbon footprint of transportation, particularly when the electric energy is sourced from renewables such as solar, wind, or hydropower (Alfaverh et al., 2023; Boudmen et al., 2024; Hassan et al., 2024; Umoren et al., 2023), (Al-Ghaili et al., 2022; Kunatsa et al., 2024; Saha et al., 2022; Tahir et al., 2024). The integration of renewable energy sources further strengthens the sustainability of electric vehicles by mitigating greenhouse gas emissions (Abdelsattar et al., 2024; Alam et al., 2023; Sinha et al., 2023).

The successful realization of electric carsharing systems depends on policymakers and necessitates extensive infrastructure enhancement alongside political backing. Among the primary objectives is the expansion of the electric charging network, particularly in urban and suburban areas (Demirci et al., 2023; Dorji et al., 2023; Icaza-Alvarez et al., 2023; Tomczewski et al., 2023). The integration of smart grids and energy-efficient technologies, including Vehicle-to-Grid (V2G) systems, is vital for incorporating electric vehicles into the broader transportation ecosystem (Almutairi et al., 2023; W. Li et al., 2023; Yassine et al., 2024).

The role of policymakers is pivotal not only in facilitating infrastructure investments but also in streamlining and regulating the deployment of electric vehicles and charging stations (Horváth et al., 2023; Sousa-Dias et al., 2024). Moreover, it is essential to enact energy policy measures that incentivize the

adoption of sustainable energy sources, fostering both the stability and efficiency of energy systems (Tantau et al., 2024; Liang et al., 2022; L. Wang et al., 2024; Reddy et al., 2023). Data-driven smart grids enhance the efficiency of energy utilization for electric vehicles and contribute to reducing grid load (Darwish et al., 2024; Esfandi et al., 2024; Muqbel et al., 2024; Venkatesan et al., 2024).

Financial incentives and subsidies, including green loans, tax exemptions, and governmental backing for renewable energy initiatives, could further accelerate the proliferation of electric car-sharing (Ahsan et al., 2023; Darani et al., 2021; Shipman et al., 2019). These measures would enhance the sustainability of urban mobility while simultaneously reducing reliance on conventional car usage (Demirci et al., 2024; Jafari Kaleybar et al., 2024; Jiang et al., 2023; Wu et al., 2024). To expedite infrastructure development, policymakers must ensure that providers have access to streamlined and efficient permitting administration processes for the installation of charging stations, particularly at strategic urban locations (Al-Ghaili et al., 2022; Annamraju and Nandiraju, 2019a; García et al., 2023; Hassan et al., 2024).

The smart city concept can positively influence the city from several aspects, including urban mobility. The establishment of a smart district has the potential to enhance the quality of life, thereby increasing its appeal. In the Czech Republic there is a smart city project, namely Špitálka, in Brno – the second biggest city of the country. This initiative aspires to mitigate mobility challenges by integrating housing units, social services, and shops within a single locale. Emphasizing sustainable mobility, the promotion of public transportation, as well as cycling and pedestrian pathways, is a critical element of urban revitalization. Through intelligent urban planning, reliance on private automobile travel is reduced through the establishment of essential facilities in proximity to residential areas. This strategy not only diminishes negative externalities such as environmental pollution but also decreases the time spent in transit (Neumannová, 2022). Overall, the smart city concept aims to enhance the efficiency and sustainability of transportation systems, thereby improving the quality of urban life. Therefore, government support for smart cities is essential, of which e-carsharing should be an important part.

The task of public policy decision-makers is to enhance the sustainability of the transportation system through the integration of electric vehicles and the reduction of traditional car usage. This requires comprehensive support for charging infrastructure, the development of the regulatory environment, and the introduction of innovative technological solutions and incentives that will result in a sustainable mobility system in the long term (Ahmed et al., 2024; Naidu et al., 2024; Sun et al., 2020; Tahir et al., 2024; Xu et al., 2022).

## Future Research Directions

Central European countries, including Hungary, Slovakia, and Romania, exhibit distinct economic, social, and infrastructural conditions, all of which shape the efficiency and adoption of e-carsharing systems (Abdi, 2022; Borghetti et al., 2023; Icaza et al., 2023). Existing studies and data frequently offer generalizations that do not fully capture the region's specific contexts. Consequently, further empirical research is required to examine the specific circumstances of individual countries and cities, considering local regulatory environments, charging infrastructure availability, economic incentives, and the evolution of public transportation habits and preferences (Briguglio and Formosa, 2023; Han and Sun, 2024). Examining the role of car ownership as a status symbol is particularly important, as it can represent a substantial barrier to the widespread adoption of e-carsharing systems. In Central European culture, car ownership carries significant prestige (Morton et al., 2016). Thus, a detailed analysis of consumer attitudes is essential, alongside strategies aimed at diminishing the importance of this status symbol and fostering openness to electric carsharing services (Dorji et al., 2023; Muqbel et al., 2024). Demand-side energy management systems are assuming increasing significance as smart grids become more widespread (Bakare et al., 2023; Esfandi et al., 2024; Wang et al., 2023). Moreover, public policy and regulatory frameworks oblige careful consideration, as they can profoundly influence the development of e-carsharing systems, particularly through localized incentives and regulations (Darani et al., 2021). The following research directions are likely to be critical for the continued development of the e-carsharing market (Zhang et al., 2024b).

Central Europe's distinct economic, infrastructural and social conditions exert a substantial influence on the development and dissemination of e-carsharing models. The proliferation of e-mobility in this region hinges primarily on government support, infrastructure development, and public attitudes (Alanazi, 2023; Lu et al., 2024; Zhang et al., 2024b). Analyzing public policies and regulatory frameworks is crucial, as regulations, tax incentives, and other policy measures across different countries and cities can substantially influence the effectiveness of electric car-sharing systems (Mulder and Klein, 2024).

Future research must be grounded in comprehensive data collection, encompassing the analysis of vehicle usage patterns, charging behaviors, service demands, and cost-effectiveness (Abdi, 2022; Ghatikar and Alam, 2023). This approach would empower decision-makers and providers to implement targeted strategies for the development and optimization of e-carsharing systems, aligning with the specific challenges and opportunities within the region. For instance, localized data analyses could assist in identifying neighbourhoods with the highest demand for expanding charging infrastructure or regions where car-sharing services could be most effectively implemented (Almutairi et al., 2023).

Moreover, it is essential to investigate the social impacts of e-carsharing systems, particularly with regard to ensuring equitable access for diverse social groups and their potential role in mitigating social inequalities (Singh et al., 2022).

Consumer attitudes and technological advancements are intrinsically connected to the future expansion of e-carsharing systems (Sun et al., 2020). In Central Europe, where car ownership traditionally carries high prestige, it is crucial to develop a deeper understanding of consumer behaviors and attitudes to facilitate the widespread acceptance and adoption of e-carsharing systems. Future research should focus on consumer behavior and preferences, particularly regarding the acceptance of electric vehicles and shared mobility services (Khan et al., 2024). The technological advancements and decreasing costs of electric vehicles significantly contribute to the future of sustainable mobility. The development of energy transfer technologies for electric vehicles promotes sustainability and cost reduction for fleet service providers (Rene and Fokui, 2024). Privacy issues and cybersecurity also require significant attention with the growth of e-carsharing systems, especially concerning the rise of AI and autonomous vehicles. This research provides recommendations for decision-makers, as they are the key participants in the success of e-mobility. Without adequate government support, e-carsharing services cannot be profitable, thus hindering providers from promoting the widespread adoption of e-mobility. For users, the economic viability holds equal importance alongside sustainability and environmental protection. Future research must concentrate on consumer behaviors and preferences, especially in relation to the acceptance of electric vehicles and shared mobility services.

## CONCLUSIONS

Electric carsharing systems in Central Europe currently occupy a mixed and relatively minor role in advancing sustainable mobility, particularly in Hungary, Slovakia, and Romania. While e-carsharing systems offer substantial economic advantages, they also encounter numerous challenges in the region. The diffusion and acceptance of electric vehicles are shaped by diverse social, economic, and infrastructural factors specific to the area.

Infrastructure development plays a pivotal role in the success of electric car-sharing, particularly with respect to the expansion of charging networks and the integration of renewable energy sources. The study emphasizes that government regulation and support mechanisms are critical incentives for promoting market growth. An analysis of public policy and regulatory frameworks reveals how different approaches in various countries—such as state support and environmental regulations—directly influence the diffusion and effectiveness of e-carsharing services.

Consumer attitudes heavily influence the acceptance of electric car-sharing. In Central Europe, where car ownership traditionally functions as a status symbol, this perception presents a significant barrier to the widespread adoption of e-carsharing. Gaining a deeper understanding of consumer behaviors and attitudes is crucial for providers to formulate strategies that mitigate the prestige attached to car ownership and foster openness toward electric car-sharing.

The study also highlights the potential for incorporating AI-based systems and data-driven decision-making in electric car-sharing. Intelligent energy management and fleet optimization will be key to future progress, enhancing both efficiency and cost-effectiveness. The deployment of artificial intelligence can significantly contribute to the sustainability of electric vehicles, optimizing energy use and aligning services more effectively with consumer demands.

In conclusion, the development of electric carsharing in Central Europe is a complex, multi-dimensional process shaped by a variety of economic, social, and technological dynamics. The findings indicate an urgent need for future research focused on localized data collection and analysis, which would enable decision-makers and providers to effectively support the further expansion and sustainable evolution of e-carsharing systems. Successful integration will require an interdisciplinary approach that brings together technological innovation, changes in consumer behavior, and the management of regulatory and infrastructural challenges.

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