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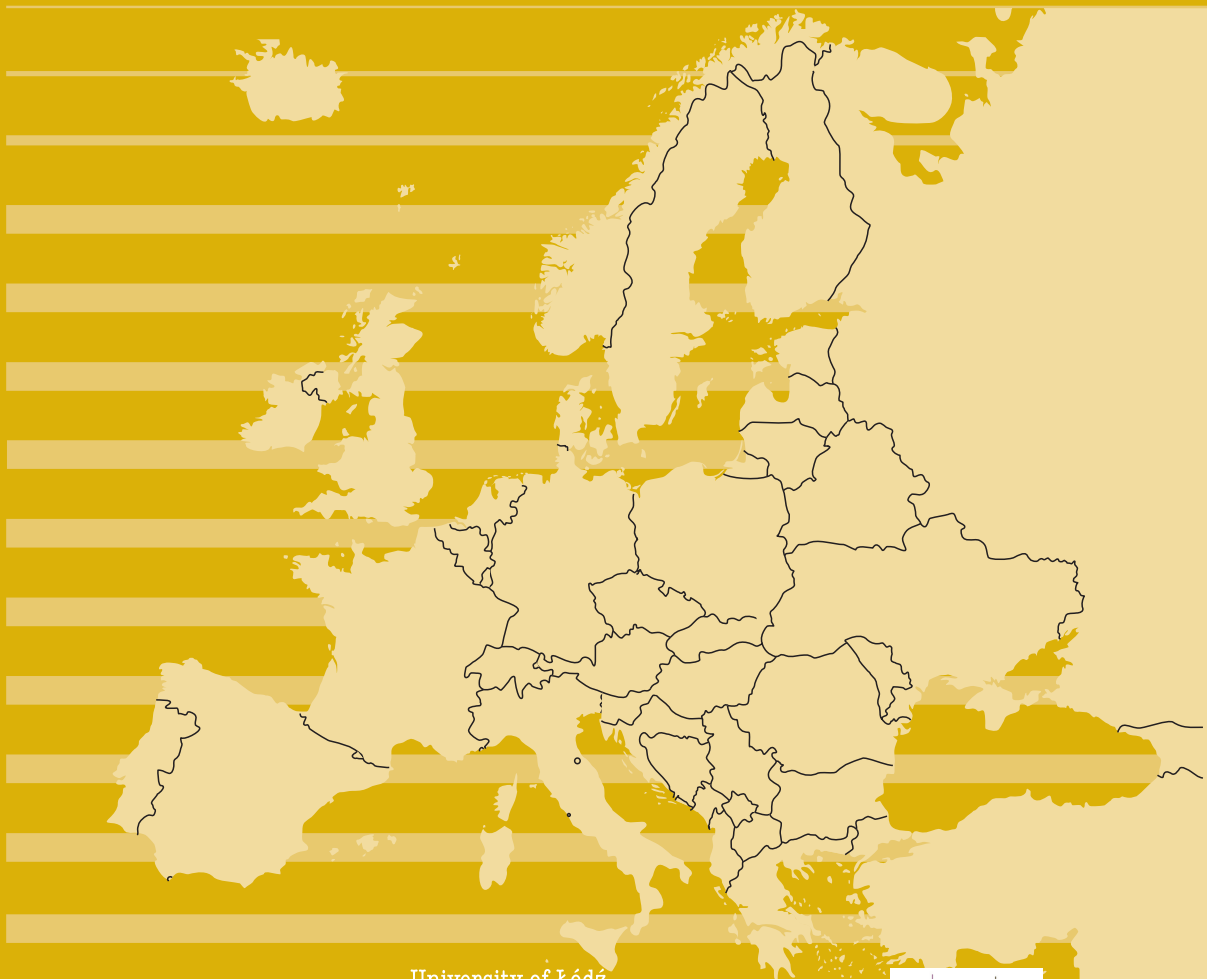

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EUROPEAN SPATIAL RESEARCH AND POLICY

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EUROPEAN SPATIAL RESEARCH AND POLICY

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Tadeusz MARSZAŁ *

30 YEARS OF *EUROPEAN SPATIAL RESEARCH AND POLICY*

The idea to launch a new interdisciplinary scientific journal dedicated to issues in social and economic space organisation originated at the University of Łódź in the early 1990s. It was a time of significant changes, especially in East-Central Europe – the end of Soviet domination in this part of our continent and profound political and economic transformations in the post-Soviet countries. The processes of integration with West-European countries initiated at that time was conducive to developing international contacts by Polish academic communities. In the field of spatial research, it led, among others, to the organisation of the 7th Congress of the *'Association of European Schools of Planning'* in Łódź in 1993. It was during this congress that I conceived the idea to undertake the establishment of a new international journal co-published by the University of Łódź and a number of foreign universities that would be interested in this initiative. I presented this proposal to Pieter H. Pellenbarg of the University of Groningen, Vladimir Slavik of Comenius University in Bratislava, and Antony Walker of the University of the West of England in Bristol. They were all interested in this idea and declared support from their universities.

A year later, in 1994, the first issue of the *European Spatial Research and Policy* journal appeared. In the course of the three decades of its existence, the composition of the editorial committee of the journal, as well as the scientific institutions engaged in its publication, underwent some modifications. Comenius University in Bratislava was replaced for a few years by Charles University in Prague (2000–2007). In 2008, the Federal Office for Building and Regional Planning in

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Bonn joined the co-publishers, replacing the University of the West of England in Bristol. Apart from Tadeusz Marszał, editor-in-chief throughout the 30 years, the editorial team included as co-editors:

– Pieter P. Pellenbarg (1994–2014) and Aleid Brouwer (since 2015) from the Netherlands,
– Vladimir Slavik (1994–1997 and since 2007) from Slovakia,
– Antony Walker (1994−1998) and Chad Staddon (1999−2006) from the UK,
– Jiři Blažek (2000−2008) from Czech Republic,
– Karl Peter Schön (2008−2017) and Markus Eltges (since 2018) from Germany.

The person actively engaged since 2010 in editorial work on *ESR&P*, who has contributed to the strengthening of its standing on the scientific publications market, is Iwona Pielesiak, supported since 2016 by Katarzyna Leśniewska-Napierała (as sub-editors, both from the University of Łódź).

During the past three decades close cooperation was established not only within the narrow group of the editorial team members, but also among all editorial board members representing numerous European and non-European countries. Every few years we all met in different academic centres to discuss matters connected with the publication of the journal and to define the directions of its further development as well as of editorial policy. Our meetings also provided excellent opportunities for initiating other forms of joint academic activities. The meetings organised by the co-operating universities were held in:

– Bratislava (1995, 2002, and 2018 organised by Vladimir Slavik),
– Lodz (1996 and 2016 organised by Tadeusz Marszał),
– Groningen (1998 and 2002, organised by Pieter H. Pellenbarg),
– Praha (2000, organised by Jiři Blažek),
– Mersin (2004 organised by Tammer Gök),
– Sao Paulo (2006 organised by Witold Zmitrowicz),
– Bonn (2008 organised by Wendelin Strubelt),
– Vienna (2010 organised by Gerhard Schimack),
– Lodz and Cracow (2012 organised by Tadeusz Marszał and Bolesław Domański),
– Tampere (2014 organised by Olli Kultalahti).

In the years 1994−2023, 30 volumes of *ESR&P* (each consisting of two issues) appeared. They contained 325 scientific articles, 97 review articles, 24 notes, commentaries and reports, and 290 book reviews. The authors of the articles and review articles represented numerous academic institutions from 44 countries, apart from Poland, mostly from the Netherlands (78), Great Britain (74), Hungary (58), Italy (39), and the Czech Republic (37).

About 1/3 of the 60 issues of *ESR&P,* prepared by guest-editors, had a thematic character:

– *'The silent revolution: electronic data interchange. Metadata and Meta governance.'* – 2003, vol. 10 no. 2 (guest-editors: Margaret Grieco, Stephen Little and Kenneth Macdonald);

– *'New trends in the geographical organisation of society: integration and differentiation within a unifying Europe'* – 2004, vol. 11 no. 1 (guest-editors: Jiři Blažek, Petr Dostál, Tassilo Herrschel and Ludèk Sýkora);

– *'New challenges for urban and regional transport policy and planning'* – 2005, vol. 12 no. 1 (guest-editor: Nicolas P. Law);

– *'In memory of Torsten Hägerstrandt (1916-2004)'* – 2006, vol. 13 no. 1 (guest-editor: Margaret Grieco);

– *'Open Method of Coordination'* – 2007, vol. 14 no. 1 (guest-editors: Nocole Schäfer and Wendelin Strubelt);

– *'Polish space in integrating Europe'* – 2007, vol. 14 no. 2 (editor: Tadeusz Marszał);

– *'Place marketing'* − 2009, vol. 16 no. 1 (guest-editor: Pieter H. Pellenbarg);

– *'South African planning scene'* − 2010, vol. 17 no. 2 (guest-editor: Marthinus S. Badenhorst);

– *'Enterprises and urban policies'* − 2011, vol. 18 no. 1 (guest-editor: Solange Montagné-Villette);

– *'Political geography of contemporary Europe'* − 2011, vol. 18 no. 2 (guest-editor: Marek Sobczyński);

– *'Geographies of ageing and well-being'* − 2012, vol. 19 no. 1 (guest-editors: Bettina Van Hoven, Aleid Brouwer and Louise Meijering);

– *'On socio-economic sustainability and robustness'* − 2012, vol. 19 no. 2 (guest-editors: Ilari Karppi, Jukka Kultalahti and Olli Kultalahti);

– *'The sustainable city: The concept, European policies and implementation'* − 2012, vol. 20 no. 2 (guest-editor: Solange Montagné-Villette);

– *'Debating planning cultures: Australian researchers in conversation with John Friedmann'* − 2014, vol. 21 no. 1 (guest-editors: Beatrix Haselsberger and Alexander Hamedinger);

– *'Planning systems facing heritage issues in Europe: From protection to management, in the plural interpretations of the values of the* past' − 2014, vol. 21 no. 2 and 2015, vol. 22 no. 2 (guest-editor: Anna Geppert);

– *'The (re-)production of peripherality in Central and Eastern* Europe' – 2017, vol. 24 no. 2 (guest-editors: Erika Nagy and Judit Timár);

– *'Crucial issues in contemporary transportation systems'* − 2019, vol. 26 no. 1 (guest-editor: Szymon Wiśniewski);

– *'Mass Immigration to Europe: A Threat or Opportunity?'* − 2019, vol. 26 no. 2 (guest-editor: Marek Sobczyński);

– *'Re-addressing the role of proximity on a microscale: The case of coworking spaces and business* incubators' − 2020, vol. 27 no. 1 (guest-editor: Grzegorz Micek);

– *'Governing circular economy: Place-specific barriers that hamper to close the* loop' − 2020, vol. 27 no. 2 (guest-editor: Viktor Varjú);

– *'The Holocaust and its consequences in the spatial* perspective' – 2021, vol. 28 no. 1 (guest-editors: Piotr Kendziorek and Andrzej Rykała);

– *'Territorial governance in the Western Balkans: Multi-Scalar approaches and* perspectives' – 2021, vol. 28 no. 2 (guest-editors: Giancarlo Cotella and Rudina Toto);

– *'Sustainable spatial planning of tourism destinations'* – 2022, vol. 29 no. 2 (guest-editors: Katarzyna Leśniewska-Napierała, Iwona Pielesiak and Giancarlo Cotella);

– *'Multi-level analysis of urban and spatial development in terms of policies and processes'* – 2023, vol. 30 no. 2 (guest-editors: Antonia Milbert and André Mueller).

The scientific profile of the journal – issues in social and economic space organisation at the local, regional and supranational levels – has remained unchanged since its foundation. The scope of the journal is defined by the concepts of space, environment, society, and economy rather than by the names of scientific disciplines.

Factors important for the editorial effort have been the changing external determinants and changes recently unfolding on the scientific publications market. I am convinced that *European Spatial Research and Policy* has been successful in meeting these challenges and maintaining high academic standards, as reflected in a growing interest on the part of the readers and an increased number of texts submitted for publication. The high standing of the journal is also reflected in its indexation in many prestigious reference bases, such as Web of Science, Scopus ERIH Plus and DOAJ. In 2022, *ESR&P* had the impact factor at the level of 0.6.

30 years of the publication of *European Spatial Research and Policy* is a good occasion to thank all those who have contributed to the success of this initiative and to express hope that the inevitable time-related changes in the composition of the editorial board will ensure not only the maintaining of the achieved high position of the journal, but also successful development of this international publication initiative in the decades to come.

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ARTICLES

Piotr GABRIELCZAK [*], **Mariusz E. SOKOŁOWICZ** [**]

IS ERASMUS GOING GREEN? THE CARBON FOOTPRINT OF EUROPEAN ACADEMIC MOBILITY AND SUSTAINABILITY POLICIES OF EUROPEAN UNIVERSITIES

Abstract. The European Union has promoted academic mobility for almost half a century. A side effect of that has been a growing carbon footprint, as most academic mobility in Europe is done by air. Based on mobility data for 2014–2020, we analysed its spatial distribution and identified dominant destinations. Juxtaposing these results with research on higher education institutions' environmental measures and policies, we have identified that the willingness to reduce the carbon footprint is emerging yet tenuous, and more declarative than actual. We recommend more decisive steps to reduce air travel within Europe, outlining the possibilities for carbon footprint reduction without harming European academic mobility itself.

Key words: academic mobility, carbon footprint, Erasmus.

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1. INTRODUCTION

All over the world, universities' internationalisation materialises in both staff and student mobility. Growing numbers of students decide to spend part of their studies in a foreign country, as do academic staff (Glover *et al.*, 2017; Hopkins *et al.*, 2016). However, due to macroeconomic, social, and individual contexts, this mobility varies greatly between countries, regions, and urban areas (Van Mol and Timmerman, 2014, p. 465).

In the European Union, for almost 40 years, academic mobility has been facilitated by the Erasmus program. Every year, the program sends abroad around 400,000 students, trainees, and staff to develop multilingualism, digital competencies, interpersonal skills, a sense of European citizenship, cultural awareness, and employability (European Commission, 2019). A side effect of this program is the increasing use of air travel, which results in a growing carbon footprint (CF). This poses a challenge to the academic world, which must search for a trade-off as international mobility provides both, much needed competencies and environmental concerns. Air travel generates between 2.5 and 4.9% of the greenhouse gas emissions responsible for climate change (Lee *et al.*, 2009, 2021). Growth in these emissions is expected to continue at the rate of 4.9% annually until 2026 (Airbus, 2007; cit. after Glover *et al.*, 2018, p. 757), while at the same time emission reductions arising from technological progress in the field are not expected to be effective before 2030 (Bows and Anderson, 2007). Air travel contributes to the CF of academic communities despite calls to travel less (Anglaret, 2018), which comes from the fact that academic mobility is largely ignored in their sustainability policies (Glover *et al.*, 2018; Mihail *et al.*, 2019).

Given the above, we aim to verify the magnitude of the environmental impact of Erasmus, based on data from the 2014–2020 period. The contribution of air transport to total greenhouse gas emissions is small compared to other sectors (energy production, agriculture, and other modes of transport) (Ritchie *et al.*, 2020). Within it, the contribution from academic mobility is even more modest. However, one cannot ignore the psychological impact that going abroad as part of the Erasmus program has on future social attitudes. Indeed, over 80% of Erasmus mobility include student travels, therefore, they occur at a point in life that can condition students' awareness and stimulate a more pro-environmental behavior in various aspects of their adult lives. For this reason, we claim that, given the many benefits arising from the internationalisation of the study and research process, the culture of mobility is essential. Still, it should take the aspect of CF to a broader extent. By identifying the scale of the CF resulting from movements under the Erasmus program, we attempt to answer the question of whether and to what extent the policies of higher education institutions (HEIs) in terms of greening their activities respond to academic mobility, and whether the program participants themselves

(both students and university employees) consider the decarbonisation aspect in their academic mobility decisions.

The next section provides a literature review focused on presenting the main facts about academic mobility and its role in generating and controlling CF emissions. Then we present the scope and methods of the research. Finally, we present and discuss the main findings. The final section concludes and provides policy implications.

2. LITERATURE REVIEW

Mobility seems to be a 'commodity of the early twenty-first century' (Cairns *et al.*, 2017, p. 170). Modern students find internationalisation as a way to benefit from being a part of the European flow of ideas and people (Cairns, 2014). Students and academics, compared to many social groups, are markedly more mobile and inclined to mobility (Sokołowicz, 2018). However, this mobility varies strongly in terms of selected directions. This refers to mobility between countries, regions, and urban areas. The directions of researchers' mobility are neither even nor random. Researchers rather travel via "narrow and fragile networks, resembling the galleries termites build," (Latour, 1987, p. 232). Firstly, these paths are strongly embedded socially and biographically. Secondly, decision to study abroad for a certain period also depend on macroeconomic context (Van Mol and Timmerman, 2014, p. 465).

Academic exchange remains an important driver of the contemporary quest for knowledge. Student mobility should not be considered separate from the movement of researchers. Both are mutually reinforcing (see, e.g., Maadad and Tight, 2014). Therefore, despite the fact that the main aim of academic mobility is to improve human capital it also results in increased scientific collaboration (Scellato *et al.*, 2015). Travelling to foreign academic destinations allows one to experience new environments and opinions, material and personal resources, and distinct forms of professional socialisation and institutional reputation that can help to inspire and facilitate creativity in academic performance (Meusburger, 2009). Hence, academic mobility stimulates new thinking patterns (Törnqvist, 2004) and is, to some extent, a sign of excellence in research-related professions (Mahroum, 2000). In academia, mobility is considered more a source of prestige and development opportunities than devaluation (as in the lower segments of labour markets) (Bauder, 2015). It even becomes an element of academic habitus (Bourdieu, 1988), which is why national governments and supranational institutions incentivise it.

As a result, a growing number of policies, implemented by HEIs, countries, and international organisations, focus on internationalisation in various forms,

recognising the benefits at not only the individual but also the societal and political levels (Wit *et al.*, 2019). These include improved research results, language skills, strengthened research, learning and teaching capacity, and positive attitudes toward democracy (Crăciun, 2015). So far, however, despite spilling over into more and more countries, such activities are still prevalent in Europe (Crăciun, 2018). Over 1.5 million students from all major world regions studied in European higher education in 2021 (Eurostat, 2023). However, a significant component of this mobility in terms of numbers is the shorter journeys made by teachers and students within the Erasmus program framework, sending 400,000 students, trainees, and staff abroad yearly. The frequency of these trips prompts attention to its two interrelated consequences: differentiated spatial and environmental consequences, especially CF.

The decision to join the Erasmus program depends on three main groups of factors: (1) macro conditions, (2) personal background, which refers to both, socioeconomic status, and social networks, and (3) personal reasons, e.g., personal development, career opportunities, experiential goals, current language skills, and willingness to improve them (Van Mol and Timmerman, 2014, p. 466). The most important macro factors attracting Erasmus students are language and climate, as well as the general academic prestige of selected host country (Rodríguez González *et al.*, 2011). Personal factors are more nuanced, therefore, classifying them is challenging, yet one could conclude that student mobility is a multifaceted, competing, and often conflicting process (Holton and Finn, 2018). However, another study suggests that key individual factors responsible for selecting mobility destination include course suitability, academic reputation, job prospects, and teaching quality (Soutar and Turner, 2002).

Rodríguez González *et al.* (2011) used gravity models to emulate the overall picture of European students' mobility within Erasmus framework. They found that despite the financial support granted by the EU and other institutions, the differences in the cost of living, along with distance, were the key factors explaining Erasmus flows. Other significant determinants include educational background, the host university quality, and the language and the climate of the host country. Furthermore, the Erasmus flows seem to be biased towards Mediterranean countries, mainly due to their superior climate (Rodríguez González *et al.*, 2011, p. 427). Meanwhile, a network study by Breznik and Skrbinjek (2020) revealed the following Erasmus program mobility patterns:

– Spain, France, Germany, and Italy are the key nodes in the student mobility network,

– Spain, Switzerland, Austria, and Poland have the best relative balance of inbound and outbound mobility,

– Spain and Italy exchange the most students with each other,

– Luxemburg, Malta, and Liechtenstein have the largest numbers of mobile students compared to the size of the country's student population.

Breznik and Skrbinjek (2020) revealed three groups of countries: (1) good receivers and senders (Spain, Italy, and Germany), (2) good receivers only (Finland, Sweden, the United Kingdom, and Portugal) and (3) good senders only (Belgium and the Czech Republic). Another study showed that most flows involved students from low-income countries who travel to higher-income destinations (Macrander, 2017). However, at the same time, new secondary centres, which also attracted mobile students, were observed in Italy, Spain, Austria, Czech Republic, Belgium, Denmark, Poland, Hungary, Sweden, and Finland (Kondakci *et al.*, 2018). Spatial variations in Erasmus mobility are similar to processes observed beyond Europe where, despite globalisation, the world of science is still "spiky" (Florida, 2005; Olechnicka *et al.*, 2019). Many studies have confirmed that geographical distance decreases the likelihood of collaboration and reduces its intensity, which was displayed by declining numbers of co-publications, co-patents, and projects in collaboration (Hoekman *et al.*, 2010, 2013; Ploszaj *et al.*, 2020; Ponds, 2009).

A factor that significantly determines the increase in the possibility of academic cooperation is the accessibility of university centres via air travel (Ploszaj *et al.*, 2020). Air travel is responsible for a significant percentage of academic mobility, thus academia is a source of the CF generated by air traffic. This presents a challenge to the academic world – it aims to benefit from international collaborations, but at the same time, in particular due to its educational function, the academia needs to be aware of the environmental externalities of such practices. Hence, contemporary HEIs face a trade-off between internationalisation as a root of new inspirations and mobility as a reason for environmental concerns. This dilemma was temporarily halted by the COVID-19 pandemic (Nižetić, 2020), with a sudden stop of mobility. However, new analyses have shown that although the pandemic contributed to some modifications, it did not lead to structural changes in academic mobility patterns, especially in its scale and the means of transportation used (Ferencz and Rumbley, 2022; Rumbley, 2020). Air travel generates between 3.5% and 4.9% of the greenhouse gas emissions that are responsible for climate change (Lee *et al.*, 2009). Growth in these emissions is expected to continue at the annual rate of 4.9% until 2026 (Airbus, 2007; cit. after Glover *et al.*, 2018, p. 757), while CF reductions arising from technological progress in air transportation industry are not expected to become effective before 2030 (Bows and Anderson, 2007).

Academic mobility is largely ignored in sustainability policies – most HEIs are not ready for any sacrifices in that field, because mobility is an integral aspect of the academic career, growing in importance (Glover *et al.*, 2018, p. 768). Without denormalisation of this practice, any significant changes in this matter are difficult to foresee. In consequence, air travel still contributes substantially to the CF of academic communities despite repeated calls to travel less (Anglaret, 2018). The overall levels of carbon dioxide emissions

from the transport sector in the 35 European countries increased substantially between 1994 and 2014. However, 2008 was a turning point for the developed world. Following the global financial crisis, the total amount of CO_2 emissions from transport in the EU and the US entered a decreasing trend. For the US this proved to be temporary, but in the EU the trend was more sustainable, indicating that decreasing CO_2 emissions are possible. This refers both to relative (per capita and per unit of GDP) and absolute (tons) terms (Mihail *et al.*, 2019, p. 691). A surprising insight comes from Wynes *et al.* (2019) who focused on the relationship between academic performance and frequency of air travel. They noticed that frequency of travelling by air had no impact on academic performance, but instead was simply typical for older researchers and those with higher positions, which indicated that it was rather associated with habits and status. Surprisingly, Wynes *et al.* also noticed that scholars specializing in "green" related topics did not tend to travel by air significantly less than others, which also proves that there is room for implementation of awareness into action.

A drastic reduction of academic mobility is hard to imagine. A possibility of such a reduction would even be unfavourable due to the growing need for scientific collaboration. Therefore, in the nearest future the academia is most likely to adopt an "avoid-mitigate-compensate" approach (Jean and Wymant, 2019). The first step in minimising the CF is, undoubtedly, realising its scale. Thus, a sound diagnosis of European HEIs is a starting point for further measures.

3. MATERIALS AND METHODS

In order to measure the impact of European academic mobility on the CF generated and examine the response to it in actual individual and organisational actions, we conducted a three-component study. The first component involved estimating the carbon footprint scale over the 2014–2020 period of the Erasmus program. The second was contextual and it assumed the form of an exploratory survey conducted among European academic institutions. It aimed at investigating the declared responses to the environmental impact of academia and the possible countermeasures taken against the generation of a carbon footprint. The third component was qualitative and it included focus group interviews (FGI) held among the community of the HEIs involved in one of the Erasmus+ Projects (European Commission, 2022).

The first part of the research analysed the general outcome of individual mobility. The data informed us about the distance covered by each trip, although

there was no indication of the means of transport in available reporting. Thus, we assumed that all trips posited at over 600 km were airborne, while for shorter distances, coaches were more popular than trains. We utilised the estimations of Hill *et al.* (2020) for the average CF per passenger-km for a trip taken by coach or plane, following their distinction between short-haul and long-haul flights[1]. We then used these conversion factors (Table 1) to estimate the total CF of the Erasmus+ program in 2014–2020.

Table 1. Conversion factors

Means of transport	**CF emission (CO_2eq. kg/pas.km)**	**Range (km)**
Coach	0.02732	(0;600]
Short-haul plane	0.07610	(600;1700]
Long-haul plane	0.09340	Above 1700

Source: Hill *et al.* (2020).

We have complemented the calculations through a survey in which we asked whether CF reduction activities are part of broader and deliberate European HEI policies. In order to do this, we asked whether carbon footprint reduction activities were part of broader European HEIs actions. We investigated to what extent these activities were incidental and selective, and to what extent they were part of a deliberate and structured environmental action agenda. For this purpose, we conduced Computer Assisted Web Interviews (between 22 March 2021 and 28 May 2021) to authorities and administrative bodies of European HEIs that participated in the Erasmus program. The institutions were asked about the frequency with which they undertook specific measures in waste management, energy consumption, green public procurement, grid- and rainwater management, and campus greening. We also asked about the introduction of "green" curricula and how they influenced staff and students' transport behaviour. We reached a sample size of 68; however, after data validation, we analysed a final number of 59 responses.

Finally, we performed FGI in three universities engaged in one of the Erasmus+ Projects (European Commission, 2022), namely Erasmus University of Rotterdam, Netherlands (EUR), Lapland University of Applied Sciences, Finland (LUAS), and University of Lodz, Poland (UL). These three universities were also significant sending institutions in the 2014–2020 edition of the Erasmus+

[1] We also performed alternative calculations based on Loyarte-López *et al.* (2020). The CF calculated with alternative conversion factors was in general slightly higher, but not substantially different.

program. UL was the 78th largest contributor (almost 4,500 trips), EUR ranked 118th (almost 3,500 trips) and LUAS ranked 537th (about 1,200 trips) among 12,860 classified sending HEIs. The FGI group at EUR consisted of 9 people (7 students and 2 administrative staff members), the group at LUAS consisted of 5 people (3 students, 1 academic teacher, and 1 member of administrative staff), while the group at UL consisted of 8 people (5 students, 1 academic teacher, and 2 members of administrative staff). We performed the FGIs according to structured scenarios to provide comparative material. Firstly, we introduced the interviewees to the scale of the CF caused by academic mobility (to outline the discussion's context). Subsequently, we discussed the various instruments of its reduction (informational and promotional, aimed at raising awareness, financial, organizational, and administrative restrictions), evaluating their effectiveness and comparing them in a mutual discussion. Finally, we discussed the popularity and effectiveness of offsetting programs.

4. RESULTS

Our database indicates almost 1.9 million conducted travels within the Erasmus framework in the 2014–2020 period, more than 80% of which were student trips and only less than one in five were executed by a staff member. According to our calculations, the average distance travelled by a student was 1,375 km and 1,755 km by a member of the academic staff. Despite the large dispersion of individual distances covered, the vast majority of mobility was by air – our distance-based approximation estimates this share at just below 83%, which is consistent with the estimate of 77% obtained based on a previous survey (ESN, 2020). As much as short or long-haul flights are defined and one could relate to a previously used standard, there is no comprehensive study about the distances covered by trains or coaches. Furthermore, in the 2014–2020 financial perspective the European Commission did not gather reliable information about transportation. This will be improved for the 2021–2027 perspective, however, for the 2014–2020 dataset, the modes of transport could not be recorded and had to be assumed. Our distance-based approximation proved to be relatively well fit as it generated a share of flights similar to that based on survey results. Moreover, we decided to focus entirely on coaches and exclude trains because of two reasons. Firstly, the existing national railway networks still function in highly regulated national markets, making their international supply sparse and dispersed (Martí-Henneberg, 2013), so we believe that coaches are in fact more common. Secondly, coaches generate more CF and from a risk-assessing perspective overestimation of the CF is more desired than underestimation.

We observed three key issues concerning CF emission of the Erasmus+ edition in 2014–2020 (Fig. 1). First, there is a strong seasonality, with peaks in September, January, and February, as well as June, corresponding to the beginning and end of semesters in most HEIs in Europe. The second observation is the steady growth trend from 2014 up to mid-2018. The third finding is that the trend wavered in late 2018, only to collapse at the end of 2019.

Compared to the total CF emission in Europe (Friedlingstein *et al.*, 2021), the Erasmus+ emission (own calculation) may seem small, but it grew from 0.0006% in 2014 to 0.0017% in 2018, only to drop again in 2019 and 2020 (due to the restrictions of the COVID-19 pandemic)[2]. The relative contribution of the Erasmus program to the total CF grew almost three times, showing that academic mobility fails to follow the global trends of emission mitigation. All in all, we estimate that in the entire 2014–2020 period the Erasmus program was responsible for emitting between 413 and 666 million tons of CO_2 equivalent. About 98% of that came from air travel – the share of contribution of CF is larger than share of flights as such, because air travel has higher unit emissions and is usually associated with longer trips (Table 1).

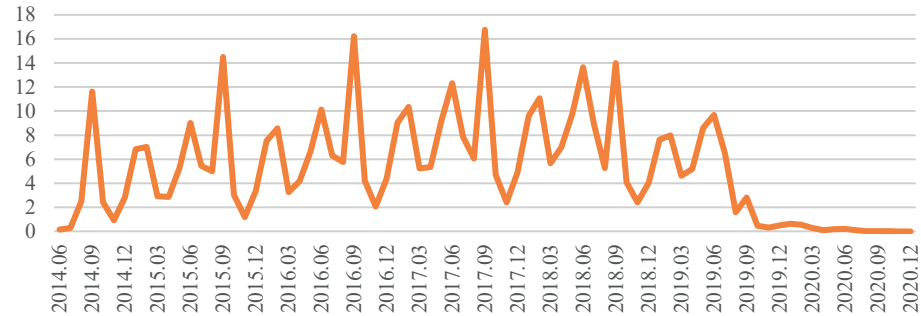

Fig. 1. CF emission of the Erasmus+ program, 2014–2020, thousands of CO2 eq. tons

Source: own work based on data from FRSE.

The drop at the turns of 2019 and 2020 was probably due to the COVID-19 pandemic and the resulting restrictions in mobility. A more puzzling question is why the intensity of travel declined in late 2018. Our research did not provide a clear explanation. One possibility could be associated with the "yellow vest" protests in France, which is one of the key nodes within the Erasmus network. In fact, Spain, France, and Italy, along with Finland, the Baltic States, and Romania, are the largest contributors to the Erasmus travel patterns – both as sending and receiving countries (Fig. 2).

[2] Detailed data is available upon request.

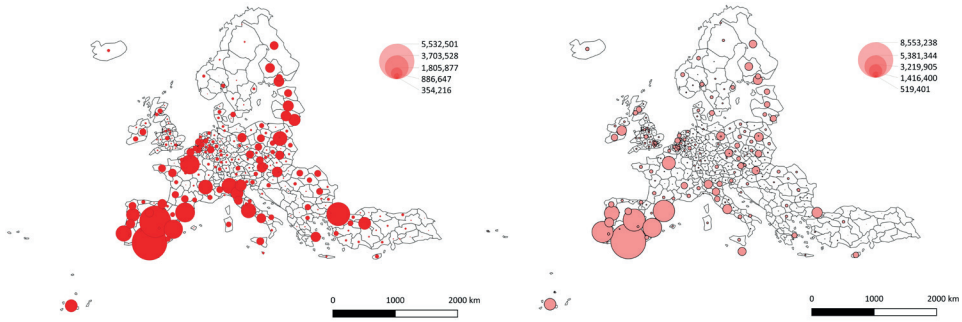

Fig. 2. Erasmus+ CF by regions (NUTS 2), aggregated 2014–2020, CO_2 eq. tons
The sending regions (left-hand panel) and the hosting regions (right-hand panel) were grouped using Jenk's classification method, which is a data-driven clustering algorithm

Source: own work based on data from FRSE.

The strong regional concentration demonstrates that the CF emission within the Erasmus+ program is granular and there are a few mobility hubs, thus sometimes even a single HEI may have a significant effect on a general scale. An increasing number of HEIs declare that they are trying to be more sustainable, but the question remains whether these actions are systemic and complex (Velazquez *et al.*, 2006). Research in the area of the academia's commitment to sustainable development is sporadic, and the findings show that, despite the efforts made and the HEIs' awareness of the need for this transformation, the transition is slow (Marrone *et al.*, 2018; Mazon *et al.*, 2020).

As demonstrated by the results of our survey, it is no different for the HEIs that are active in the Erasmus+ program. Their main measures for building a sustainable university were waste management, a standard recycling system (due to the alignment of European law in this matter), usage of recycled materials, and monitoring energy consumption. More systemic actions are declared infrequently. For example, the systemic inclusion of closed water circuits and rainwater management, the introduction of codes of good practices, or the obligatory inclusion of sustainability-related courses in curricula are more in the middle than at the top of the indications (Fig. 3).

From a transport behaviour perspective, tangible measures towards sustainable transport still seem to be an exception rather than the rule, although there are important manifestations of positive actions. To start with, 20 HEIs have declared that they utilize mobility strategies very often or often, making it the most commonly used transport-related measure. However, it ranks somewhat distantly compared to other measures. Additionally, 9 HEIs declared reimbursement of the costs of business trips based on their CF. These were the only two relatively commonly used measures directly associated with international mobilities.

Fig. 3. Measures declared by HEIs for the benefit of the environment

Source: own work.

In terms of generally transport-related policies, it is pleasing that 12 out of the 59 HEIs surveyed have their own bicycle rental systems. It is also worth noting that a relatively large number of HEIs support their employees fully or partially in the use of public transport. However, HEIs subsidise students in this respect to a much lower extent. From the perspective of the CF of academic mobility, it is particularly worrying that measures to minimise it are very rarely or almost never declared. Although some universities indicate that they implement CF calculators, they do little to eliminate that footprint at the source.

Our final research step was performing focus group interviews with people engaged in the Erasmus program – students, teachers, and administrative staff. The FGI scenario was focused on academic policies that already were or could be implemented in order to make Erasmus and general mobilities greener. We concentrated on two main problems associated with limiting the carbon footprint of the Erasmus program: emission reduction and offsetting. Moreover, we not only discussed existing types of policies, but also stimulated our participants to propose original solutions, which would be suitable for a relatively large public university.

When asked about the mitigation of negative ecological impacts of the Erasmus program, participants naturally focused on emission reduction, while the issues of offsetting had to be suggested by moderators. At first, the discussions gravitated around the problem of raising awareness about the importance of making academic travel greener. However, all the groups noticed that awareness itself may not transfer to actual behavioural change if not supported by other incentives, especially that engagement in green travel is often limited by difficulties in arranging an eco-friendly trip. Organising a flight is relatively easy, so it becomes a more and more tempting alternative if green travel becomes more challenging. Thanks to well-developed customer services, air transport is much more user friendly and skills required to schedule, e.g., a railway trip are by far less common. Moreover, staff members added that in some case they felt the organisational pressure to make travel quick and cheap, which naturally forced them to select air travel.

In all groups there was a consensus that awareness was not enough without financial instruments to promote green travel. Naturally, there was no doubt that financial incentives, such as additional support for people who select low-emission transportation modes, were a desired form of encouraging the academic society to reduce emissions. Surprisingly though, there was also a general agreement that financial disincentives, such as fees for excessive emission, were controversial, unfair, and should not be used in order to promote green attitudes. Ecological issues should not be promoted with negative connotations if they are to be widely accepted.

Interestingly, though, the FGIs participants tended not to take their individual perspective on CF reduction, but instead they rather switched to the perspective of the institution in which they worked or studied. This led them to a constatation that, despite the need for positive stimulation, some compulsion was also necessary and basic rules about emission reduction simply needed to be forced in order to be effective. Furthermore, the importance of sufficient monitoring was stressed, as providing detailed information, especially about individual contributions, would probably create social pressure, thus motivating the academic society to enhance emissions' reduction.

When it came to proposing solutions for emission's reduction, FGI participants proved quite proactive. Some of their ideas, such as additional coverage for people selecting sustainable transportation, were actually already included under the new Erasmus framework. This is due to the fact that the groups were mostly composed of students, who lacked proper information about the new version of the Erasmus program. Still, the groups managed to suggest some novel and easy to apply ideas. One example was teaching mobility students how to ride a bicycle (if necessary) and how to use bicycle routes and city bicycles at their destinations. Another idea was to organise holidays for mobility students, so that, e.g., they would stay in the host country for the winter break rather than travel back and forth in a short time. One more idea focused on utilising ecological activities in

the educational curriculum, e.g., providing additional credits. This last idea is an example for a very simple offsetting, which was the main theme for the second part of the FGI scenario.

Offsetting carbon footprint was not very popular among the respondents. Participants at LUAS claimed that none of them have used offsetting, though they would like to if only they had better knowledge on how to use it and more accessible offsetting plans. Participants at UL also had very limited knowledge of any offsetting schemes that could be implemented in order to facilitate the Erasmus program. At EUR only one participant claimed to have used offsetting in the past, but it was stressed that it was more of a way to make oneself feel better than an effective way to deal with carbon footprint. In fact, in all the groups it has been noticed that offsetting was non-pedagogical, because it promoted absolution rather than mitigation of emission. As stressed by one of the participants at EUR, carbon neutrality was a "false claim" because it could be done at relatively significant levels of current pollution, so neutrality without emission reduction was not sustainable. This suggests that offsetting should be used only when options for avoiding or reducing CF were implemented at first.

Moreover, as it requires undertaking further actions independent from the travel itself, it also generates costs. It would only make sense if HEIs had detailed long-term plans for offsetting which are typically missing. Such plans are associated with two types of barriers in implementation. Firstly, they should be supported by some kind of an offsetting fund that would be fed whenever members of the academic community select high-emission transport, but this would be a financial disincentive (or negative incentive), which is generally considered undesired. At LUAS it has been stressed that such additional costs would be especially harmful if applied towards students.

Secondly, offsetting is effective only on a large scale and participants tended to criticize it as ineffective because it could bring results only after too long a period. This last remark may be associated with the fact that forestation and investing in renewable energy sources were the only forms of offsetting that were noticed by all the participants. However, as one of the participants at UL noticed, providing a catalogue of potential offsetting activities and allowing students or staff members to choose which offsetting would be supported in reference to their own carbon footprint would probably increase interest in that kind of activities. It could also be organised in a form of citizen budget, where members of the academic community could vote for an initiative supported, e.g., during the forthcoming academic year. Both ideas focus on the idea of choice. All the FGI participants agreed that offsetting as such should be mandatory, if it was to be effective, but a particular form of offsetting should not be imposed. Giving the right to choose the offsetting project makes academic travellers more engaged and devoted, which is in line with the self-determination theory of education (Brooks and Young, 2011).

5. DISCUSSION AND CONCLUSION

A drastic reduction in the mobility of students and researchers is hard to imagine. Such a reduction would even be undesired from the perspective of the increasing need for scientific collaboration. Therefore, adopting an "avoid-mitigate-compensate" approach (Jean and Wymant, 2019) seems to be the most likely strategy for academic communities in the coming years. The first important step in minimising the CF is measuring its scale and regular monitoring. Thus, a sound diagnosis of European HEIs as CF producers is a starting point for further actions. Linking the scale of CO_2 emissions to travel funding should be the next step, but our survey proves it to be one of the least frequently indicated measures. Admittedly, the surveyed HEIs increasingly display a pro sustainability attitude. Still, the pace remains unsatisfactory, especially regarding more direct support of students and employees in changing their transport behaviours towards greener ones. This is in line with previous research findings that HEIs are in reality relatively active in their attempts to reduce carbon emissions, but this is still not enough and more is expected from them.

Another conclusion from our research is that emission reduction and offsetting require proper institutional nesting. To start with, these issues need to be comprehensively organised in long-term strategies planned on a scale large enough. Moreover, there is a need to communicate that such strategies are implemented. Raising awareness is the first step to make a behavioural change, and that is possible only if the academic society is sufficiently well educated about the need for action and informed about the actions actually taken and planned for the future. Awareness should be supported by decent monitoring, positive financial incentives along with some mandatory regulations, especially in terms of offsetting, which is considered to be more controversial. All the implemented instruments should be well propagated, especially among students who seem to be the victims of information asymmetry in the academic society. There is also a need for HEIs and their partners to be more creative in designing programs for supporting sustainability. So far, when it comes to offsetting, many members of the academic world cannot imagine schemes beyond forestation and renewable energy.

New institutional solutions and organisational changes undertaken by HEIs also need some flexibility. They could be more flexible in their procedures, and each new rule or requirement makes the organisation even more rigid (Lomas, 1999). Introducing sustainable strategies in HEIs demands much flexibility due to the complexity of the matter (Blanco-Portela *et al.*, 2018), so limiting it would be counter-effective on a larger scale. However, this is only possible with actions taken on an international level, e.g., the EU. HEIs may be active actors of international mobilities, but the sustainability challenge still requires coordination and standardisation on a level where HEIs are regulation takers rather than policymakers. European Agendas must notice this circumstance.

One must also point to the still existing necessity to implement coordination and standardisation on a level exceeding the regulating capacity of HEIs. There is a significant lack of practical skills when it comes to planning a trip by means of transport alternative to air travel and this barrier cannot be reduced without an intervention on the level of international policy makers. An online tool for scheduling travel by railway or bus routes would be a desired improvement, but in order to create such a tool proper EU authorities should provide common European travel conditions and standards for these modes of transportation. This is in particular visible in terms of railway networks – as long as they remain national, the use of railway transport (probably the best alternative for aviation) in international mobility will be limited.

In the context of the research results obtained, we assume little likelihood of reduction in academic travel. We have identified a firm conviction that, without strong and consistent legal and financial regulations at the European and national levels, travel by air will dominate. The incidental decline in travel caused by the COVID-19 pandemic has not caused significant structural changes in this regard, and future predictions for the development of academic mobility in Europe assume its growth. Moreover, the development of initiatives involving the emergence of meta-organisations focused on strategic partnerships and alliances (particularly the newly launched European Universities) makes it likely that another significant type of actors will emerge, contributing to increasing the mobility of HEIs students and staff (Ferencz and Rumbley, 2022). In such a case, the development of internationalisation through remote communication will be complementary rather than substitutive to this trend. Therefore, the most feasible solution is a concerted effort to provide a transportation alternative to air transport at the European scale, primarily through trans-European railroads. "Europe stands out as a region of the world that may be somewhat well-placed-by virtue of the density of countries in a relatively small geographic region and highly developed public transportation systems relative to many other parts of the world-to implement changes in travel patterns for academic mobility (Ferencz and Rumbley, 2022, p. 286)."

To conclude, the awareness of the importance of sustainability and its popularity as an idea is growing, but it requires a more strategic approach and more institutional support. Not only because of how crucial this issue is, but also because of the economies of scale that are very strong in that field, which means that emission reduction or successful offsetting can only be efficient when done on a large scale.

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FROM SUSTAINABILITY TO RESILIENCE: TRACING THE TRANSITION PATH FOR SPATIAL PLANNING POLICY IN GREECE

Abstract. Sustainability and resilience are currently key analytical concepts with wide acceptance among different disciplines. This study initially attempts a comprehensive analysis of the current policy to specify the meaningful elements for integrating these concepts into spatial planning theory and practice. Then, a critical review of the Greek spatial planning policy aims to shed light on its evolution in relation to the two paradigms. The findings show that the actual shift from sustainability to resilience remains to be observed and that more attention should be focused on the political rather than the administrative aspect of planning.

Key words: sustainability, resilience, planning policy, spatial planning, Greece.

1. INTRODUCTION

On the global level, governments, non-governmental organisations, and businesses are increasingly recognising that cities and wider spatial systems need to become more sustainable and more resilient to natural and man-made hazards. Resilience can be considered as a way of thinking and acting that leads to the achievement of sustainability (Metaxas and Psarropoulou, 2021) and as

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a necessary condition for sustainability by strengthening the capacity of societies to respond to crises (Lebel *et al.*, 2006).

The ongoing discourse surrounding sustainability has revolved around the imperative to strike a balance between environmental quality, social equity, and economic prosperity, while the economic, environmental, and social 'pillars' of resilience have been mentioned in the literature on multiple occasions, as the review of Weber (2023) has demonstrated. The same author indicates the significant strides and continued expansion of research on the concept of resilience over the past 35 years. Although the two concepts differ substantially in regard to definition and origin, an overall positive trajectory may be observed in the joint examination of sustainability and resilience, indicating that they share comparable objectives and methodologies. However, such research is still in its infancy (Weber, 2023). While many perceive sustainability and resilience as marginally nuanced viewpoints regarding the same phenomenon, many others regard them as separate conceptual paradigms, wherein the conservation objectives of sustainability stand in contrast to the adaptation objectives of resilience (Lew *et al.*, 2016; Roostaie *et al.*, 2019).

In spatial planning, some scholars view the two concepts as working in combination with or complementary to each other, with resilience introducing new and innovative ways of thinking and planning (Thoidou and Foutakis, 2015), while others consider that sustainability tends to be replaced by resilience as both a frame and a principle (O'Hare and White, 2013; Davoudi, 2012). Several studies have acknowledged potential synergies between the two concepts (Rega and Bonifazi, 2020), particularly regarding the understanding of the dynamics of socio-ecological systems (Rega and Bonifazi, 2020; Folke *et al.*, 2010; Abel and Step, 2003). Rega and Bonifazi (2020, p. 14) advocate "to refocus the attention on sustainability as the guiding paradigm of spatial planning, while resilience can and shall be used as a useful descriptive concept indicating a specific property of complex systems".

The scope of this study lies in exploring the integration of sustainability and resilience concepts, principles, and challenges into the Greek spatial planning system and policy. In this respect, the second section of the paper encompasses a description of the conceptual evolution of sustainability and the role of spatial planning, followed by the identification of contemporary challenges in respect to resilience. This brief literature review sheds light on critical issues to be examined in the empirical part of the study. Section 3 states the objectives and methodology of this study, while section 4 presents and discusses the results based on a critical review of the past 25 years of spatial and urban planning policy in Greece. The conclusions include the main findings and limitation of the study, as well as issues to be addressed in future research.

2. BACKGROUND OF THE STUDY: FROM SUSTAINABILITY TO RESILIENCE

2.1. The conceptual evolution of sustainability and the role of spatial planning

In 1987, the Report of the World Commission on Environment and Development 'Our Common Future' defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987, p. 37), emphasizing a long-term perspective and taking a key step toward incorporating the concept into legal frameworks (Mondini, 2019). As Holling (2001) approached it, sustainability is the ability to create, test and maintain adaptive capacity. An object is sustainable when it can survive or be maintained over time, therefore sustainability is its property or ability to continue its existence. It serves as a fundamental principle for all aspects of development. Sustainable development presupposes a balanced relationship and progress in at least three interdependent areas: Environment – Economy – Society. The review of historical sustainability literature based on the three-pillar conception made by Purvis *et al.* (2019), concluded that perceptions regarding the pillars could be roughly divided into two groups: those that view the three as separate perspectives and those that adopt a systems approach. The authors also argue that this three-pillar conception is "a gradual emergence from various critiques in the early academic literature of the economic status quo from both social and ecological perspectives on the one hand, and the quest to reconcile economic growth as a solution to social and ecological problems on the part of the United Nations on the other" (Purvis *et al.*, 2019, p. 681).

This "triple bottom line" model gave way to broader considerations of other relevant issues, adding new dimensions to the model (Mondini, 2009). In some approaches, the 'political dimension' constitutes another core element of the notion (Andrikopoulou *et al.*, 2014), while in others (Rogers, 1997; Wassenhoven, 2022) 'culture' is proposed as a fourth, separate, pillar. More recently, the technological dimension has been identified as an additional pillar, impacted by the latest strategies of the European Communities such as smart growth and the rise of the smart city concept (Bottero *et al.*, 2014). These dimensions have to coexist within an integrated perspective (Bottero and Mondini, 2009), although each has given rise to distinct discourses. The fact that they are frequently addressed independently restricts a practical application of the concept to mere rhetoric (Giovannoni and Fabietti, 2013). Sustainability also includes the processes through which the above objectives are achieved, as well as the integration of individual and collective stakeholders in decision-making processes (Jordan, 2008).

Although the environmental dimension dominated the use of the concept initially (Tasopoulou and Asprogerakas, 2023), over the years the need to understand

the human or social dimensions of environmental issues has been highlighted (Bennet *et al.*, 2017). Giovannoni and Fabietti (2013) provided a concise literature review on the evolution of the concept, from the 'environmental discourse' and the relationships between people and nature, to the 'social' and 'business discourse'. They acknowledged that in recent years, growing concerns over climate change, poverty, widening disparity and the tensions engendered by social inequalities, have led national and international institutions, policy makers as well as the professional and academic community to place greater focus on social and environmental sustainability worldwide. The discussions at Rio+20 focused on the importance of both social and environmental concerns. In 2015, at the Summit in New York, the UN adopted the "2030 Agenda for Sustainable Development", a broad action plan aiming at the transition to a sustainable and resilient development model (UN, 2015). It includes seventeen (17) Sustainable Development Goals (SDGs) structured around five main pillars: (a) People, (b) the Planet, (c) Prosperity, (d) Peace, and (e) Partnership, recommending their adoption by both developed and developing countries. The SDGs address all aspects of the sustainable development approach, forming individual thematic fields. Indicatively, SDG 11 'Sustainable cities and communities' and SDG 13 'Climate action' can be directly linked to spatial planning policy and practice. SDG 11 emerged as a stand-alone goal to address the need for sustainable development from an urban perspective, favouring cities and human settlements that are more inclusive, safe, resilient and sustainable (Berisha *et al.*, 2022). It addresses a variety of issues, such as affordable housing, infrastructure, and cultural and natural heritage (Nabiyeva *et al.*, 2023). There is also recognition of the cross-cutting nature of urban issues, which have an impact on several other Sustainable Development Goals, including SDGs 1, 6, 7, 8, 9, 12, 15, and 17. SDG 13 'Climate action' reflects the effort to mitigate climate change and its effects, calling for action at different organisational levels (Filho *et al.*, 2023). SDG 13 considers both adaptation and mitigation and focuses on fostering resilience, including climate change adaptation strategies into national planning and policies, tracking the status of financial commitments made to address climate change, and, finally, enhancing capacity on climate change (Campbell *et al.*, 2018). Many of the SDGs and their targets can also be achieved in ways that would enable adaptive responses to climate change, for example, those related to resilience in SDGs 9 and 11, relating to infrastructure and urban settlements respectively. SDG 17 'Partnerships for the Goals' constitutes a horizontal action, highlighting the important role of governance in SDGs' implementation.

For Medeiros (2020), SDG 10 'Reduced inequalities' and SDG 11 'Sustainable cities and communities' are the two goals that include actions distinctly related to issues of human geography and spatial planning. His paper underlines that the SDGs would be more effectively implemented through a holistic approach to spatial planning; for example, if the focus was shifted from the amendment of income

differences to the reduction of territorial inequalities within and between countries. This would enable territorial cooperation and the multi-level governance approach to be integrated into the planning objectives. In relation to the "Urban" SDG, Klopp and Petretta (2017) have indicated the difficulties in its practical implementation and have argued that it has the potential to encourage and guide the necessary reforms in cities if it is based on local institutions and initiatives and shaped by open, inclusive processes. As a multi-dimensional concept, spatial planning should feature prominently in the implementation of the SDGs. Furthermore, it may be viewed as an alternative response to economic-centric approaches in the shaping of strategic planning policies (Medeiros, 2020).

A general overview of relevant regulations in other EU Member States exceeds the scope of the present paper. Nevertheless, based on comparative analysis studies that were conducted at the EU level, by 1997, ten years after the Brundtland Report, only a minority of states had fully embraced the notion of sustainable development and its three pillar-approach in their environmental agenda. Even in cases where broad sustainability objectives had been agreed, the implications in practice, especially at the local level, were not yet observable (EC, 1997). In the years to come, most Member States passed legislation to address the purpose of planning, the most common purpose being to steer development (28 countries) and/or to pursue sustainable development (18), followed by the protection of land and other assets (14), and the involvement of citizens in decisions on spatial development (11) (ESPON, 2018). Local development strategies tend to address a much wider set of issues, such as energy efficiency, sustainable mobility and sustainable urban development in general, city compactness and reduction of soil consumption, and heritage preservation. The inspiration of integrated urban regeneration plans, inter-municipal partnerships or sustainable urban strategies has had noticeable local impacts in several states. One crucial observation is that although EU Cohesion Policy and other sectoral policies seek to strengthen economic investment and employment, promote more sustainable development, enhance resilience to shocks, widen accessibility to services, etc., the spatial dimension of the policies and actions that support these objectives is not always recognized (ESPON, 2018).

2.2. Approaching resilience and contemporary challenges

Resilience is about the ability to respond to complexity and uncertainty. It is a concept that has been used in literature as early as in the 1960s (Kakderi and Tasopoulou, 2017). However, its approach and meaning can vary substantially depending on the discipline in which it is applied, such as ecology, engineering, socio-ecological systems, climate change and adaptation, urban planning and disaster risk management (Assumma *et al.*, 2021; Datola *et al.*, 2022). Although it

has attracted broad interest over the last couple of decades (see literature review in, for example, Pendall *et al.*, 2007; Meerow *et al.*, 2016), its conceptualisation nevertheless still lacks consistency and a shared definition (Cutter, 2016). Fundamental questions remain to be answered, such as "resilience to what, and resilience for whom", whether it is conceived as (static) outcomes or as (dynamic) processes and how these static conditions and dynamic processes affect places (Cutter, 2016). As a concept, it aims to describe the stability of a system against short-term or long-term interference, in tandem with the system's ability to recover and return to a state of equilibrium (MacKinnon and Derickson, 2013; Martin, 2012). It also refers to the capacity of adaptation, reorganisation and transformation (Kakderi and Tasopoulou, 2017) and it has often been linked to the study of the dynamics of complex systems (Holling, 2001).

Holling (1973, 1996) introduced the concept of resilience in ecosystems by distinguishing between ecological and engineering resilience. Since then, resilience has grown in popularity among academics and policymakers as a prism through which authorities (whether national or local) and emergency services comprehend issues like pandemics, natural disasters, or terrorist threats. Moreover, it provides a framework for creating strategies that can adapt to the demands of an ever-changing and competitive environment (McAslan, 2010).

Introduced in the context of spatial planning in the late 1990s, urban resilience is perceived as a complex and multi-dimensional concept which defies easy definition. Urban resilience research primarily employs two meanings: the first is associated with nature and ecosystems and the second concerns the social and civil components (Davoudi *et al.*, 2012 cited in Feng *et al.*, 2020). In their compilation of definitions pertaining to urban resilience, Assumma *et al.* (2019) have concluded that the emphasis is on the dynamic behaviour of resilience processes on both spatial and temporal scales. Cities and settlements should be able to return to a state of equilibrium in cases of economic crises (e.g. the financial crisis of 2008), unprecedented social transformations (e.g., refugee crises), or extreme natural phenomena, whether sudden (i.e., shocks, such as earthquakes, floods, fires, heatwave events) or long-term (i.e., disturbances, such as climate change) (Asprogerakas and Tasopoulou, 2021; Asprogerakas and Tasopoulou, 2019; Markada and Asprogerakas, 2020; Lagarias, 2023). According to Datola *et al.* (2022), an assortment of urban attributes can contribute to maintaining and improving urban systems' resilience. These attributes are the following: (1) robustness, (2) redundancy, (3) diversity, (4) integration, (5) inclusivity, (6) equity, (7) iterative processes, (8) decentralization, (9) feedback, (10) transparency, (11) flexibility, (12) forward thinking, (13) adaptive capacity, (14) predictability, and (15) efficiency.

Resilience is emerging as an important concept in the debate on climate change. Broad discussions have developed on two main approaches to this major contemporary environmental issue: adaptation and mitigation. Adaptation refers to anticipating the extreme effects of climate change to deal with its current and future

impacts by taking appropriate measures to prevent or minimise the damage that may be caused. Mitigation aims to address the causes and to reduce and stabilise the levels of heat-trapping greenhouse gases in the atmosphere to prevent climate change. These challenges provide the umbrella for a range of policies related to the environment and the impact of human activity on it. In the relevant dialogue, a broad consensus is emerging that (Leichenko, 2011): (a) to be prepared for climate change, cities need to become resilient to a wide range of shocks and pressures; and (b) efforts to enhance climate change resilience need to be combined with efforts to promote urban growth and sustainability.

The "Sendai Framework for Disaster Risk Reduction 2015–2030" recognises the primary role of the state in disaster risk reduction and the responsibility of other actors, such as local authorities and the private sector. In this context, spatial planning is identified as a field of action from the national down to the local level. Relevant actions could include integrating disaster risk assessments into land use policy, mapping urban sprawl and adopting appropriate standards for construction and urban equipment (UNDRR, 2020). Risk management requires intervention in the subsystems and operating parameters of the spatial system and implies acceptance of the implementation of public policies that can be distinguished between spatial (urban design and spatial planning) and other sectoral policies with spatial implications. Spatial policy may be able to coordinate multi-disciplinary, integrated strategies to address the pressures and challenges that shape risks which requires a multidisciplinary and integrated strategy; spatial policy can serve as a coordinating mechanism in this regard.

Resilience was first introduced into spatial planning with the purpose of developing mitigation strategies for environmental threats (Abdulkareem *et al.*, 2018) and adapting social and institutional frameworks (Spaans and Waterhout, 2017). In relation to the objectives stated above, the role of spatial planning can be twofold: (a) to coordinate adaptation policies at the national and regional level to ensure sustainable development prospects, and (b) to implement these policies at the local level through land use planning and the establishment of terms and conditions for infrastructure development. The current mission of spatial and urban planning is to offer solutions to address the complexity of the phenomenon and its multiple dimensions and thus reduce vulnerability to the expected impacts (Davidse *et al.*, 2015; Asprogerakas and Tasopoulou, 2021).

Ecosystem-based approaches are considered an important part of climate change adaptation and an underlying principle within spatial planning. Ecosystem services (ES) are acknowledged as a necessary framework for linking human and natural systems and for guiding spatial planning towards sustainability, on an anthropocentric basis (Ronchi, 2018). In Ronchi's words (2018, p. 149), "the ES concept provides the opportunity to reconceptualise Nature as a human-based perception understanding the human dependence on Earth's life-support system in a reciprocal relationship". Integrating ES into spatial planning enhances resilient

development (Pozoukidou *et al.*, 2022). The United Nations (UN) International Convention on Biological Diversity (UN, 1992) defined the ecosystem approach as "a strategy for the integrated management of land, water and living organisms that promotes conservation and sustainable use in an equitable manner," while humans, with their cultural diversity, are recognised as a key integral component of ecosystems. The conservation and sustainable use of biodiversity and its components should be addressed holistically, considering socio-economic and cultural parameters. Its implementation is based on twelve complementary and interrelated principles (CBD, 2004) while a broad participatory approach is required in the formulation, implementation and monitoring of related policies, involving stakeholders at the local, regional, national and international levels (Asprogerakas *et al.*, 2020).

Central to this dialogue is the role of Blue and Green Infrastructure (BGI), both conceptually and as a tool for managing development in a way that protects natural and cultural resources and promotes urban resilience. Although BGI has its conceptual roots in ecosystem conservation efforts, it has recently acquired new dimensions that are more broadly linked to sustainability goals (Foster *et al.*, 2011). The European Commission has defined Green Infrastructure (GI) as a strategically planned network of natural and semi-natural areas, as well as other features of the environment, whose design and management aim to provide a wide range of ecosystem services (EC, 2013). This definition is based on three key characteristics crucial to the effective application of BGIs in sectoral policies: connectivity, multifunctionality, and links to spatial planning. Having been associated with ecological resilience and focused mainly on preservation, GI development was perceived until recently "as a solution-oriented and cross-sectoral approach to spatial planning" (Pozoukidou, 2020, p. 13). Nonetheless, today it is perceived as "a framework or even a strategy that identifies interventions which can help tackle major environmental and socioeconomic needs and capitalize on opportunities" (op. cit.). Its associated strategies, policies and tools seem to find ground for application at all levels of spatial planning: national, regional/metropolitan, local/urban.

3. OBJECTIVES AND METHODOLOGY

This paper attempts a critical review of the past 25 years of spatial and urban planning policy in Greece, with the aim of (a) illuminating critical issues of the way principles and aspects of sustainable development are integrated, and (b) tracking the emergence of the concept of resilience. The analysis emphasises the institutional framework, with reference to the objectives, the content of the tools and their implementation in practice.

The research methodology is based on content analysis (Weber, 1990; Potter and Levine-Donnerstein, 1999) of the legal texts that regulate the operation of Greece's spatial planning system. This enables the study of topics for which it would be difficult to obtain and access quantitative data. The present approach encompasses both manifest and latent content (Gaur and Kumar, 2018; Bengtsson, 2016).

More specifically, the research begins with a review of the past 25 years of spatial and urban planning policy in Greece, with the aim of enlightening critical issues regarding the integration of principles and aspects of sustainable development. The research includes analyses of (a) the legislation (approved by Parliament), and (b) the explanatory statement to Parliament (an official document that analyses the purpose of the proposed regulations). The object of the research is the direct reference to the concept of sustainable development but also the emphasis on specific pillars covered by the proposed regulations (Table 1) with allusions to the objectives, the content of the tools and issues related to their implementation.

To track the emergence of the concept of resilience in the Greek spatial planning system, further analysis covers the current legislative framework. The concept is linked to new dynamics and relationships that have developed over the course of evolution of the international framework for sustainability, thus forming the "coding scheme" of the approach (Gaur and Kumar, 2018). The research covers references to meanings and the level of integration of sub-concepts, namely climate change, territorial inequalities, disaster risk assessment and the ecosystem approach. The presentation of the results covers spatial planning at two levels: (i) national / regional, and (ii) local (Fig. 1).

Table 1. The main spatial planning regulatory framework in Greece

Law number / year of issue	**Content**	**Level ***
L.2508/1997	Sustainable residential development	L
L.2742/1999	Spatial planning and sustainable development	N/R
Instructions, 2008	Instructions for the monitoring/approval of General Urban Plans studies of Law 2508/97	L
L.3894/2010	Acceleration and transparency in the implementation of Strategic Investments	L
L.3986/2011	Urgent Measures for the Implementation of the Medium-Term Financial Strategy Framework 2012-2015	L
Ministerial decree - GG 3545B/2021	Technical Specifications for General Urban Plans	L
L.4269/2014	Spatial and urban planning reform - Sustainable development	N/R, L
L.4447/2016	Spatial Planning - Sustainable development and other provisions	N/R, L

Tab. 1. (cont.)

Law number / year of issue	Content	Level *
L.4546/2018	Incorporation into Greek legislation of Directive 2014/89/EU „establishing a framework for maritime spatial planning".	N/R
L.4685/2020	Modernisation of environmental legislation, incorporation into Greek legislation of Directives 2018/844 and 2019/692 of the European Parliament and of the Council'	N/R, L
L.4759/2020	Modernisation of Spatial and Urban Planning Legislation	N/R, L
L.4864/2021	Strategic investments	L
Ministerial decrees - GG 3545B/2021 and 510B/2022	Technical Specifications for Local Urban Plans Technical Specifications for Special Urban Plans	L

* N/R: National / Regional, L: Local

Source: own work.

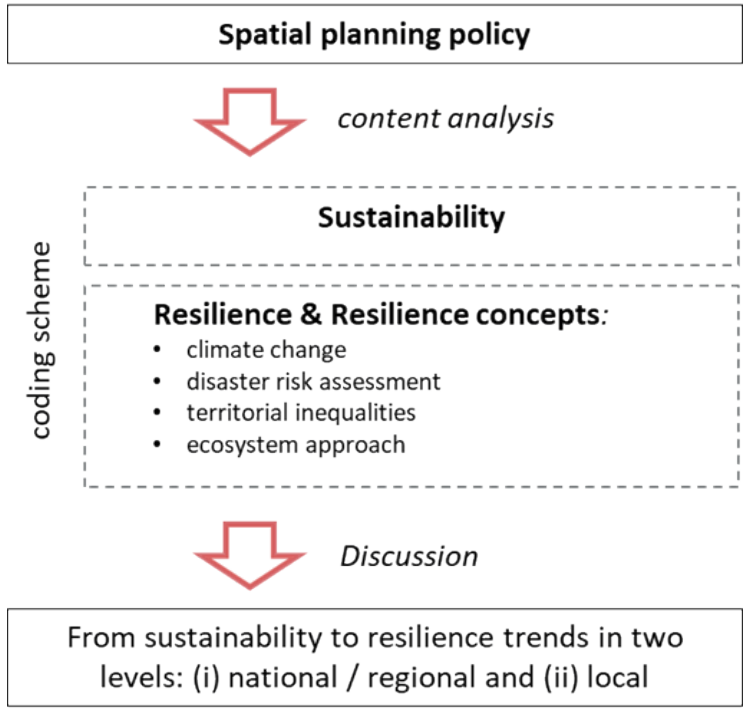

Fig. 1. Research metodology

Source: own work.

The Greek spatial planning framework provides two levels: (a) Spatial planning at the National and Regional level has a predominantly strategic character and encompasses medium-term or long-term objectives, guidelines for spatial development and economic activities and provisions for the protection of sensitive areas; and (b) Urban planning at the local level is for the most part regulatory, governing, for example, the establishment of land uses, the plot ratio, etc. It includes the Local Urban Plans (LUPs), which regulate the sustainable spatial organisation and development of Municipalities, the Special Urban Plans (SUPs) which cover (i) spatial interventions, and (ii) the development of strategic investment projects (of public and private interest), irrespective of administrative boundaries, and the street layout Implementation Plans. All the upper tier frameworks are binding for the lower tier urban and local plans. The system is centralised and executive power is exercised primarily by the Ministry of the Environment and Energy (Asprogerakas and Melissas, 2023).

4. RESULTS AND DISCUSSION

4.1. The concept of sustainability in the Greek spatial planning policy

The concept of sustainability first appeared in the country's spatial planning legislation in the second half of the 1990s, when the basic laws on spatial planning attempted to conform with the wider Europeanisation of planning policies (Yiannakou and Tasopoulou, 2012). On the strategic level, the law attempted to approach spatial planning through a broader framework that identifies economic, social, geographical and political developments in the European Union and beyond, incorporating the principles of sustainability. This pursuit is reflected in the objectives of the law, which highlight the triptych of integrated, balanced and sustainable spatial development and point out the need to use spatial planning to secure the country's comparative geographical, natural, cultural and productive advantages.

The legislative framework as it stood in the late 1990s showcased the role of spatial planning for strengthening the variety and diversity of the national territory, balancing the diffusion of development and promoting economic and social cohesion. These principles were implemented through the establishment of frameworks for spatial planning and sustainable development at the national and regional level, to meet developmental, social and environmental objectives in a uniform manner. The concept of environmental planning was integrated into spatial planning by "incorporating elements of the natural environment into planning practice" (Law 2742/1999).

The pursuit of sustainability is emphatically reflected in the title of the tools proposed by the law: "Frameworks for Spatial Planning and Sustainable Development." At the national level, the "General Framework for Spatial Planning and Sustainable Development" (2008) sought balance between the three main objectives at the core of spatial planning: development, stability and protection. The Special Frameworks may cover special geographical areas, such as coastlines, islands or mountainous regions, or certain nationally vital sectors or branches of productive activities (tourism, aquaculture, manufacturing, etc.). The Regional Frameworks encompass strategic goals and directions, among others, for territorial organisation and management, the protection and restoration of the environment, as well as the protection, promotion and preservation of the natural and cultural heritage of the Region. They constitute the intermediate level where national and local spatial planning "meet" and at the same time form the common frame of reference for the coordination of individual policies, programs and investment plans at all levels of government, from central to local (Table 2).

Table 2. Sustainability in spatial planning legislation over time (1997–2010)

Basic Legislation	L.2508/1997, L.2742/1999	
Policy directions	Conformance with the wider Europeanisation of planning policies. Sustainable development.	
Objectives	*Strategic planning* • Integrated, balanced and sustainable spatial development. • Securing the country's comparative geographical, natural, cultural and productive advantages. Incorporation of natural environment elements into planning practice.	*Urban planning* • Address of major "universal" environmental issues: urban sprawl vs the compact city model, cultural heritage protection, social inclusion etc. • Integrated approaches to urban interventions. • Upgrading of the built environment and protection of the natural environment.
Tools	*Strategic planning* • Frameworks for spatial planning and sustainable development at the national and regional level.	*Urban planning* • Strategic urban plans, Street layout plans. • Urban renewal.
Implementation emphasis	Integration mainly of the environmental aspects of sustainability, land use zoning.	

Source: own work.

Concurrently, new integrated tools are introduced in an obvious attempt to cover the individual pillars of sustainability, the so-called "Plans of Integrated Urban Interventions" (SOAPs) for urban areas and the "Areas of Special Spatial Interventions" (PEHPs) that apply at the sub-regional level. SOAPs are developed to promote integrated urban planning strategies in cities or individual neighbourhoods, as well as

in wider urban areas, that face critical and complex issues of delayed development, breakdowns in social and economic cohesion, environmental degradation and worsening quality of life. SOAPs are multi-sectoral in their objectives and thus have an integrated character. They are distinct from the urban renewal provisions that provide for physical planning interventions to meet urban planning needs and address problems within the urban area (Asprogerakas, 2016; Asprogerakas, 2020a). The *PEHP* is, in principle, a restorative and defensive tool, as it is meant for areas that exhibit unique and/or significant spatial development problems. It features a composite, integrated approach, combining regulations and actions with spatial and development goals and enabling synergies between the relevant policies (Asprogerakas and Kallioras, 2020).

At the local level (Law 2508/1997) the main challenges included urban sprawl, deprived areas, the degradation of important cultural heritage sites, worsening air and water pollution, etc. Tools of "strategic" urban planning were introduced at the municipal level, to identify areas of special protection and define the patterns of residential development. Another objective is striking a balance between urban land uses and arrangements for environmental protection (referring to both natural and cultural resources). The concept of the compact city emerges as a basic planning principle, with a clear direction for minimising residential areas, expansion in 'critical zones' and ensuring adequate residential density to deal with the problem of 'urban sprawl'. Tasopoulou and Asprogerakas (2023) have indicated a transition, at least in rhetoric, from outdated approaches that "see the city as a sum of rigid 'zones' and absolute separation of uses and functions" to an "effort to develop the city with a single plan – framework".

Apart from the institutional framework directly concerning spatial planning, Greece's spatial planning practices have also been impacted by a series of legislative initiatives launched over the course of the economic crisis. In the 2010s (Table 3), spatial planning policy was intrinsically linked to the fiscal crisis the efforts to address it (Klabatsea, 2012, Vitopoulou *et al.*, 2015; Gemenetzi, 2022). Since 2010, the strategic investments policy has significantly promoted the economic dimension in an effort to simplify the provisions and processes of environmental and spatial legislation, and provide an attractive investing environment. This approach clearly favours the economic pillar of sustainability over the environmental one.

The related provisions adopted internationalised capital attraction models with an emphasis on the use of space as a recipient of investments (Asprogerakas, 2020). In this context, the main goal was to reduce the time needed for the plans to be completed. Also, the planning levels were clearly distinguished into strategic and regulatory, and responsibilities were allocated in accordance with the new administrative division of the country (Tasopoulou, 2021). Sustainable development was defined according to the definition of the 1987 Brundtland report. However, the promoted objectives and relationship with sustainable development of the attempted reform came under heavy criticism from the scientific and professional community, which put forth the following main arguments (Tasopoulou and Asprogerakas, 2023):

– The absence of substantial reference to the purpose and strategic directions that would ensure all dimensions of sustainable development, as emphasis was placed instead on the role of space as a receptor of economic activities to the detriment of public benefit, efficiency and environmental protection;

– The role of powerful economic actors was strengthened. While this choice could enable new development prospects, it nevertheless shaped a new, more elitist governance model which limited access to development processes to the more powerful players.

In 2020, many of the provisions regulating the spatial planning system were modified. Beyond sustainable development, 'sustainable spatial planning' is defined as "the spatial, territorial and environmental dimensions of sustainable development, together with those related with rational spatial organisation." The revised legislation includes new references to the concept of sustainability, such as "the sustainable exploitation of regional energy potential, with priority given to renewable energy sources" (Law 4759/2020). Tasopoulou and Asprogerakas (2023) have noted that the concept of sustainability has been explicitly incorporated in the reform efforts of the last decade, at least in rhetoric, although the impact of the term in shaping the content of spatial planning tools is not evident. Over time there has been a shift in emphasis from the environmental pillar to that of economic sustainability, depending on the policy priorities.

Table 3. Sustainability in spatial planning legislation over time (2010–2022)

Basic Legislation	L.3894/2010, L.3986/2011, L.4269/2014, L.4447/2016, L.4546/2018, L.4759/2020, L.4685/2020
Policy directions	Flexibility and efficiency.
Objectives	Capital attraction and accumulation.
New tools	Flexible tools for investment projects. Maritime spatial planning frameworks.
Implementation emphasis	Economic efficiency, Effective integration of resources into the development process.

Source: own work.

4.2. Integrating resilience into spatial planning policy and practice

Resilience

No explicit reference to the concept of resilience was included in the legislative framework (including the related specifications), for spatial planning between 1997 and 2020. According to all the relevant legislation, the main objective of the spatial planning system is to bolster the sustainable development policy. The

regional spatial planning frameworks provide guidelines for spatial development, and emphasise the specific development characteristics of each region to ensure equal integration at the national, European and international levels and the sustainable use of energy potential.

In 2020 (Law 4759/2020), resilience was directly associated with maritime spatial planning and integrated coastal management. Recent amendments (Law 4864/2021) to the strategic investment framework, apart from reinforcing the economic parameters of sustainability over the environmental ones (Tasopoulou and Asprogerakas, 2022), explicitly incorporated the notion of resilience for the first time. Specifically, "the resilience and the ability of the physical, residential and economic-social subsystem to smoothly adapt to the effects of the investment" is set as one of the parameters to be considered in the application for an investment to be designated as strategic.

Climate change and disaster risk assessment

As forecast, the evaluation of the established Regional Spatial Frameworks necessitates that their content be adapted and brought up to date, with particular emphasis on, inter alia, addressing the problems of climate change and natural disasters. Provision is also made for interventions in areas with critical spatial development problems (see above Areas for Special Spatial Interventions), which require special planning and a coordinated programme of measures and projects (e.g. addressing the impact of major projects on man-made activities, as well as emergencies caused by landslides, floods and other disasters, managing areas with special problems). Moreover, in the context of sustainable, rational and integrated spatial development of maritime-area activities, Law 4759/2020 establishes an integrated approach for all relevant activities and uses while also seeking to conserve marine biodiversity and ensure resilience to the effects of climate change.

Urban planning tools have been substantially bolstered with content since 2020. The LUPs are the primary vehicle for the introduction of measures to adapt to climate change, address emergency events and manage the consequences of natural and technological disasters and other threats. SUPs provide similar measures and may also be developed especially to address the consequences of natural disasters. Neither tool may be revised until five years after adoption, with certain exceptions, one of which is the need to address extraordinary urban planning needs caused by natural or technological disasters and risks. This provision reflects a government consideration to afford urban planning a certain degree of flexibility in adapting to unforeseen and emergency situations. Moreover, the approval of these plans ("main study") entails the formulation and approval of "supportive" studies: the Strategic Environmental Assessment Study, Geological Study and Hydraulic Study to temporarily delimitate existing streams (flood line definition), together constitute a supplementary framework that can safeguard certain aspects of the resilience of the regions in question.

Diving into the recent specifications for these two types of plans, it becomes evident that they entail certain aspects of resilience, as these were detected in the introduction section. LUPs are governed by the principles of sustainable spatial development. Within this context, "they promote climate change mitigation and adaptation, as well as resilience and security from natural and man-made risk factors." The "main study," based on the planning needs of the area, includes all supplementary studies or technical reports related to urban mobility, climate change adaptation, emergency needs, flood and fire maps, soil erosion, vulnerability assessment, etc. Two distinct chapters of the study (analysis – diagnosis phase) are devoted to (a) the recording of climate – microclimate data and problems attributed to climate change, and (b) the identification of an emergency management network (escape routes, refuge areas, etc.). Certain vulnerability elements are analysed and depicted in maps. Accordingly, the proposal development phase is concerned with plans to address emergencies and adapt to climate change. These plans include specific adaptation measures, integration of the urban plans in the operational plans for both pre-empting and responding to emergencies, establishment of infrastructures and interventions to prevent and address disasters, and the introduction of measures and proposals for the utilisation of the urban plan at the post-disaster stage.

The national and regional-level Climate Change Adaptation Plans, the National Energy and Climate Plan and the Emergency Management Frameworks must all be considered when developing the spatial plans for both land and sea (Lazoglou and Serraos, 2021). The National Climate Change Adaptation Strategy includes measures that concern the formulation of studies and management plans for risk prevention, and the coordination of the competent ministries-agencies. The Regional Climate Change Adaptation Plans concern the 13 Regions of Greece.

Since the 1980s, Greece's civil protection system has been shaped by efforts to address earthquakes and their fallout. L.4662/2020 attempted to introduce a modern framework through the issuance of a series of General Civil Protection Plans for Emergency Response and Immediate Management of the Consequences of various disaster events such as (i) Floods, (ii) Forest Fires, (iii) Earthquakes, (iv) Technological Accidents, as part of the harmonisation with European Directive SEVESO III, and (v) for the response to a Volcanic Eruption in Santorini. Optimal disaster management requires the existence of a structured emergency plan intrinsically linked to the existing spatial planning system (Tsilimigkas *et al.*, 2018; Theodora, 2020; Pitides *et al.*, 2023; Dandoulaki *et al.*, 2023).

According to research by Asprogerakas (2022), planning for civil protection starts with a risk assessment for a given area. The above-mentioned civil protection plans have a certain spatial dimension and include limited actions that could be integrated into spatial planning tools:

– the identification of sites for the temporary deposition of solid waste, biowaste and rubble resulting from the disaster event;

– the identification of places where citizens may gather for the subsequent organised evacuation;

– the identification of sites for the reception and accommodation of persons affected by an earthquake (camping sites);

– the adaptation of the road network to allow the evacuation of the affected persons without impeding the access of emergency and relief vehicles.

These actions are mainly local in focus, and municipal authorities play a major role, facilitating their integration into the proposed spatial planning tools, especially at the municipal level.

Ecosystem approach

At the regional and metropolitan levels, the Greek spatial planning system provides provisions that promote the organisation of green networks and proposes specific programs/ action plans and pilot interventions. However, specifications at the lower planning levels seem to lack details on how to evolve the efforts to record the green elements and establish a green (and blue) infrastructure, especially based on an ecosystem approach.

There is a particular interest for the adoption of the ecosystem approach as a parameter for Maritime Spatial Planning (MSP) (Directive 2014/89/EU), to combine environmental and social objectives and ensure intersectorality and cooperation at different levels. This may also lead to a shift towards a broad participatory approach to marine management and monitoring (Asprogerakas *et al.*, 2020). MSP shall consider land-sea interactions and, more generally, the principles of sustainable management. Greek maritime spatial planning places support for sustainable development and the spatial coherence between maritime and coastal spaces at the core of its objectives. Besides, the "integrated management of the coastal zone" considers the vulnerable nature of coastal ecosystems and landscapes by definition.

Territorial inequalities

The established Regional Spatial Frameworks place particular emphasis on, inter alia, addressing the issues of territorial cohesion. A provision is also made for intervention in areas with critical spatial development problems and special planning to bolster the development of disadvantaged areas such as Greece's borders, mountains and islands. At the urban planning level, territorial inequalities do not appear to be addressed with specific proposals, although an extensive analysis of the demographic characteristics – developmental nature is incorporated into the initial phase of the study.

5. CONCLUSIONS

This study begins with a comprehensive review of current policies related to the concept of sustainable development and the shift to resilience, including the 2030 Agenda for Sustainable Development, to identify sub-concepts for its integration into spatial planning. This entailed addressing issues such as climate change, territorial inequalities, disaster risk assessment and the ecosystem approach.

It then provided a critical review of the past 25 years of Greek spatial and urban planning policy, with the aim of exploring the integration of sustainability and resilience into spatial planning policy and practice. The analysis demonstrates that Greek spatial planning has yet to make the transition from sustainability to resilience, although the concept has been generally expressed and certain fragmented efforts are evident. The legislation enacted over the past 25 years enshrined sustainability as a fundamental tenet, albeit with emphasis placed at times on the environmental and at others on the economic dimension, while the social dimension remains largely neglected. Contemporary institutional documents contain no explicit references to the concept of resilience, except in a few cases involving strategic investments, but there are elements that refer to efforts to deal with issues such as climate change, disaster risk management and the ecosystem approach in plans specifications.

The content analysis in this paper is limited to the policy implied by the institutional framework. More research is required to verify the policy's implementation through spatial planning in practice. Experience has demonstrated that spatial planning fails to meet its goals and often deviates from them. Greece is currently nearing the conclusion of institutional spatial planning reforms, and is expected to start implementing the 'new' policy. Concerning the reforms, it should be noted that they do not formulate a clearly defined policy, contrary to the institutional framework of previous decades. This conclusion is further supported by the fact that explanatory statements submitted to Parliament do not include either feasibility analyses or objectives of the planning policy. Regarding their implementation, the competent Ministry is currently pursuing an ambitious programme to finish multi-level spatial planning over the next five years, part of which is funded by the Recovery and Resilience Facility. It presents an opportunity to promote planning practices with specifications and guidelines aimed towards achieving resilience. This implies a larger emphasis on the political rather than the administrative aspect of planning.

Civic participation poses a sustainability-related challenge that should be addressed in further research. Traditionally, Greek spatial planning has lacked such processes. This shortcoming has been attributed historically , to institutional deficiencies in establishing relevant mechanisms on the one hand and, on the other, to the personal perceptions and values of those involved in plan-making (local government, planners) (Tasopoulou, 2013, 2015). This has meant that even in cases where they were implemented, participation procedures remained a formal-

ity, leaving the field open for informal initiatives and interventions. (Tasopoulou, 2015; Serraos and Asprogerakas, 2019).

This paper attempts to shed light on the adoption of the principles and aspects of sustainable development and the concept of resilience in Greek spatial planning policy as a reference for international audiences. Moreover, the relevant assessment aims to aid in the formulation of spatial policy by the Greek Ministry of the Environment and Energy going forward, while also facilitating the work of other governmental agencies and actors that deal with policies with spatial implications. The adoption of the concepts that shape the resilience approach applies to all levels of decision-making and includes both specialised tools, such as for natural disaster management, and spatial policy instruments.

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TRANSPORT ACCESSIBILITY CHANGES IN METROPOLITAN REGIONS: HIGH-SPEED RAIL CONNECTION FREQUENCY ESTIMATION

Abstract. This article focuses on a very narrowly specific segment of this issue, considering the impacts of HSR in the long term, not as transport arteries connecting the most important metropolitan areas but, on the contrary, as an internal factor of development within a metropolitan region. The paper aims to transfer the present operational European HSR commuting connection frequency experience to a generally applicable frequency estimation formula. Through a quantitative approach, the research analyses the total sample of 1,446 train connections from 10 European metropolitan regions. It answers the secondary research question of what the range of accessibility change between the metropolitan core and the intermediate city is after introducing HSR connection inside metropolitan regions in the time of 1 hour of journey. The estimation model formula calculates the optimal number of HSR connections between the metropolitan core and intermediate city in the HSR developing countries. It is derived and verified from the

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analysed dataset values. The potential operational change scenarios are presented and described based on the example of 34 metropolitan city pairs.

Key words: metropolitan region, intermediate city, accessibility, frequency, travel time, high-speed rail (HSR).

1. INTRODUCTION

Society demands speed, efficiency, comfort, and sustainability as vital characteristics of daily travel (McBride, 1996; Cwerner *et al.*, 2009). There is even higher pressure on society nowadays to use sustainable means of transport for daily trips to school, work, and leisure activities. New technologies brought new possibilities for travelling both inside the city and for longer distances.

This paper follows the current political discussion about bringing new opportunities for intermediate cities situated on railways and the challenges mentioned in Martí-Henneberg (2015) about planning and promoting intermodality for intermediate cities and their respective hinterlands, as they need to consolidate their positions as nodal points within the HSR network.

The primary research goal of the presented study is to seek a transferable operational experience for countries developing HSR networks based on the currently developed European HSR operational models. That is why the frequency estimation model will be proposed to estimate a potentially optimal HSR operational frequency based on the sample of 10 European metropolitan regions. In total, 34 city pairs of metropolitan cores and intermediate cities meet the criteria for evaluation. The paper focuses on a specific segment of HSR network operation: HSR commuting delimited by 1 hour of the operational distance between the metropolitan core and the operated intermediate city.

The paper is divided into the following two parts. The first part of the paper (Sections 3 and 4) describes the methods used to create the research dataset and presents the dataset itself. The paper also deals with secondary research questions: firstly, how the range of a daily number of train connections changed when comparing the situations before and after the introduction of HSR connections, and secondly, how travel time changed inside metropolitan regions after the introduction of HSR connections. The second part of the paper (Section 5) presents the frequency estimation model itself and describes the variables used. Subsequently, the model is calibrated by the introduced dataset. The synthesis of the model calibration and dataset analysis results reveal different scenarios of HSR introduction. These scenarios are described afterwards.

The novelty of the presented paper lies in the scale of the analysis dealing with the topic of HSR commuting inside metropolitan regions and primarily in

introducing the formula estimating the potential frequency of HSR connections between the metropolitan core and intermediate city. The synthesis of the analytic results brings different scenarios for HSR intra-metropolitan region operational models.

The paper has the following logical structure. Section 2 is framed by the previous research on intermediate HSR stations/cities and the benefits and constraints HSR commuting brings. Section 3 specifies the methodology of the dataset creation and describes the analysed metropolitan dataset. Section 4 presents secondary results according to each case of the studied pairs of a metropolitan core and an intermediate city. Section 5 presents the frequency estimation model and discusses the limits to our analyses and interpretation, and Section 6 concludes the whole.

2. HIGH-SPEED RAIL COMMUTING

Albalate and Bel (2012) reviewed several reasons for introducing new HSR infrastructure (travel time reduction between metropolises (Straszak, 1977; Givoni, 2006); overcoming congestions (Barbosa, 2018); improved accessibility of underdeveloped and remote regions (Monzón *et al.*, 2013); and modal split change (Bergantino and Madio, 2020). There is more than one formula for deploying and operating HSR, as Campos and de Rus (2009) and Perl and Goetz (2015) emphasised. It depends on several factors, most importantly geographical conditions (terrain and urbanisation) and historical development, which influence the national policies for HSR implementation (Tapiador *et al.*, 2009; Martí-Henneberg, 2013).

High-speed rail (HSR) was originally designed to compete with air travel between metropolises and to gain a part of the modal split back into trains. Operational distances of 400 to 600 km emerged as competitive (Garmendia *et al.*, 2012a; Givoni and Dobruszkes, 2013; Vickerman, 2015). The priority of the first lines was to make the connection as fast as possible due to economic objectives (Vickerman, 1997; Givoni, 2006). Negative aspects such as the "tunnel effect," which produces economic disproportions between territories occurred, where only metropolises benefited from the new HSR lines (Vickerman *et al.*, 1999; Gutiérrez *et al.*, 2006; López *et al.*, 2008). The stop policy changed at the next HSR expansion, which made the network denser, and the tunnel effect was partly side-lined. Larger and medium-sized cities and regional centres benefited from the next extension of the HSR network (Ureňa *et al.*, 2009; Vickerman, 2015). Small cities usually avoided these benefits, although some exceptions occurred (Ureňa *et al.*, 2012).

The new segment of HSR operation between metropolis-intermediate/small cities was introduced because the competitive ability of HSR was proved on distances of less than 200 km or around 1 hour (30-90 minutes) of travel time as

an alternative to private car trips. (Ureňa *at al.*, 2009; Garmendia *et al.*, 2012b; Vickerman, 2015; Moyano, 2016; Moyano and Dobruszkes; 2017; Matas, 2020). This connection brings new travel opportunities with an essential effect on the resident-workplace location and local economy (Chen and Hall, 2012; Mohíno *et al.*, 2017; Moyano *et al.*, 2019). Blum *et al.* (1997) have brought a complex economic perspective in their overview, which states that the final effect for the labour market can be very heterogeneous in small cities inside metropolitan areas. Vickerman (2015, p. 158) stated: "In general, although larger and medium-sized cities on high-speed rail links have benefited..., and even some smaller ones on national networks..., the performance of smaller intermediate stations has generally been poor." Firstly, a HSR station does not need to directly lead to economic development and new firm location in the city (Banister and Berechman, 2001; Albalate and Bel, 2012). Secondly, new HSR stations creating additional conditions (e.g., cheaper building site and salary level) can significantly attract a specific segment of activities (Vickerman and Ulied, 2009; Matas *et al.*, 2020). Thirdly, faster connections can lead to labour migration and people commuting to the metropolis every day (Guirao *et al.*, 2017, 2018). The third scenario is the crucial reason for processing this study.

Several studies have been written on metropolitan commuting and economic opportunities resulting from new HSR stations inside the metropolitan areas. These studies usually focus on Spanish metropolises Madrid and Barcelona (Moyano, 2016; Guirao *et al.*, 2017, 2018) but additionally also on London (Garmendia *et al.*, 2012b), Paris (Mohíno *et al.*, 2018), and German intra-regional commuting (Heuermann and Schmieder, 2014). These studies conclude that the travel time reduction and associated costs/ affordable ticket prices condition the commuting trips. However, other factors also influence travel behaviour and need to be considered. Commuting as a specific travel behaviour concept requires a specific operational timetable regarding time intervals when everyday daily activities begin, mainly in the morning. The principle of a "fast train at the right moment" is unsuitable for everyday commuters with the specific daily rhythms of user activities. Commuting benefits are secured by providing the equivalent train supply for the way back. The number of daily connections or frequency, together with travel time change, are the key quantitative factors influencing the general quality of the connection (L'Hostis and Baptiste, 2006; Moyano, 2016).

The authors state that small cities are most influenced by HSR, and station location (central, lateral, outlying/peripheral) matters for the subsequent city development (Mohíno *et al.*, 2018). Distances of 30 to 200 km (1 hour) are ideal for HSR commuting. These routes are most efficiently served by the particular segment of HSR trains, operated mainly as domestic service with higher-stop frequency and lower ticket prices than long-distance trips (Garmendia, 2012b; Moyano, 2016; Guirao, 2018). The success (occupancy rate) of HSR services depends on the willingness of inhabitants to commute in the context of microeconomic scale condi-

tions such as the unemployment rate, salary level, and housing prices, especially in remote regions (Heuermann and Schmieder, 2014; Guirao, 2017, 2018). The successful implementation of HSR services used by commuters was observed in Great Britain in the case of Ebbsfleet and Ashford stations, and mainly in Spain, where HSR commuting has been a much-discussed topic after the economic crisis in 2008.

Estimating the direct and indirect economic benefits of joining the HSR network is challenging. However, this study does not aim to research the economic effects of a new HSR station. The scope of this paper is the analysis of operational schemas and geographical attributes. Its content indicates the European background of transforming the everyday experience in the HSR developing countries and extending the literature on HSR commuting in metropolitan regions.

3. DATA AND METHODS

The definition of travel time by the new high-speed rail service between the metropolitan core and the intermediate city is the key factor for the study. One-hour travel was defined as the default condition to include such an HSR connection in our data sample for analysis. This condition corresponds to the expected typical working day. It can be assumed that usual working hours lie between 8 and 12 hours daily. Working hours are commonly scheduled during the day, so night trains were excluded. Under this assumption, seven services constitute regular high-speed services once per two hours to the station. This minimum service frequency allows reliable daily commuting connections, not only for work activities. High-speed services are often operated on various routes from smaller towns in the morning and back from metropolitan areas in the afternoon to meet specific demands from commuters during specific times. The frequency of seven daily services indicates a stronger relationship between the intermediate regional city and the metropolis, which can also be supplied by two other services - before and after working hours.

As the research focuses on the extent to which time accessibility benefits residents of regional cities in the hinterland of metropolitan cities based on participation in an HSR system, population thresholds were also established for selecting regional centres. A city's population had to be no more than 50% of a metropolitan city and no larger than 500,000 inhabitants, which corresponds to the usually simplified threshold for the existence of a metropolitan core in a city system in European conditions (Moreno-Monroy *et al.*, 2021). Therefore, cities such as Turin were not included in the research as the benefits of connecting it to Milan by HSR would be less substantial for cities with populations in the tens or hundreds of thousands. Only the travel time for a direct connection of the fastest tier of trains

was considered. It can be assumed that when traveling to/from metropolitan cities, people want to spend as little time as possible on the train.

The research data was based on two primary sources. The European Rail Timetable (2019, formerly known as the Thomas Cook European Timetable), which provides timetables for selected rail lines in all European countries, was used as the source for the high-speed analysis. The data spans from October 2019 until recently and is thus not biased by the Covid-19 pandemic. The data for conventional train services was then based on the historical records of the European Rail Timetable, working with the years before the construction of HSR on the studied routes, precisely 1978, 1987, 1995, 2000, 2005, and 2010 (Fig. 1).

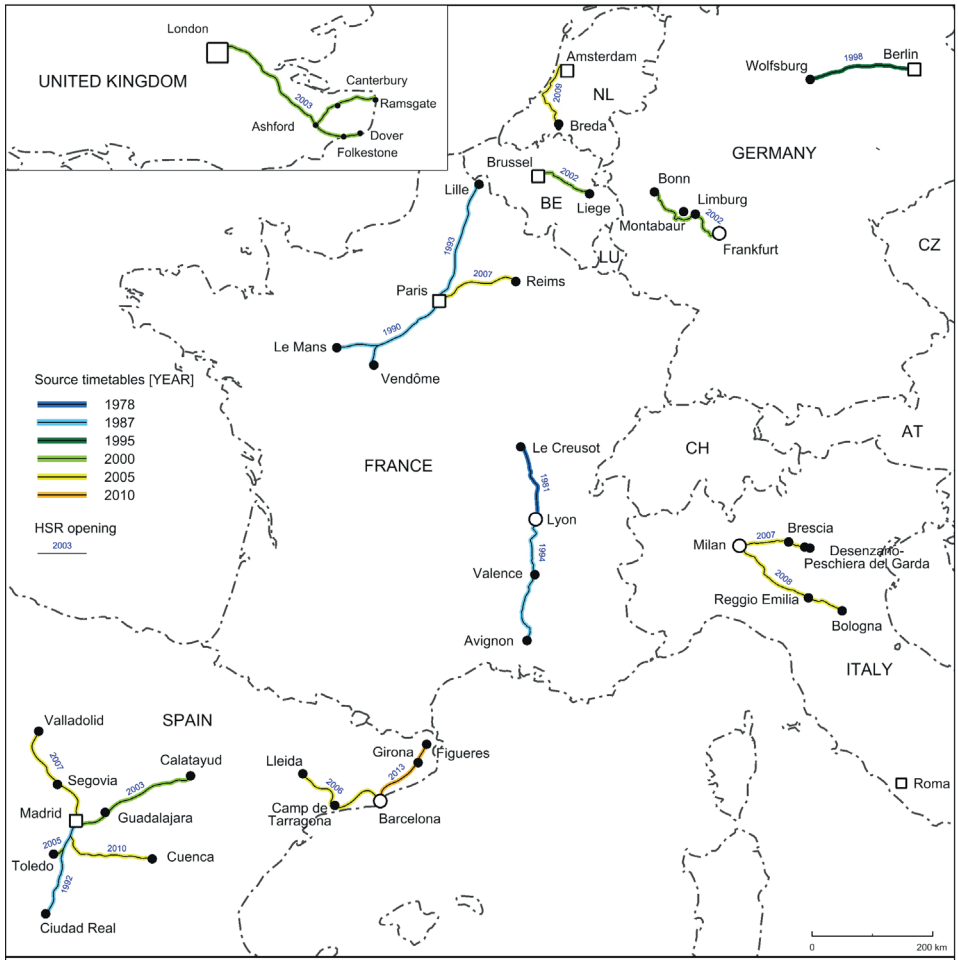

Fig. 1. Cities and railways included in the study

Source: European Rail Timetable, 2019; RRG GIS Database, 2022; own work.

The resulting data sample, on which the research is based, contains data on all conventional and high-speed connections for each identified relevant pair of a metropolitan core and an intermediate regional city. The database contains 34 metropolitan core–intermediate city pairs, for which 1,464 connections were recorded (737 conventional and 727 high-speed), including their total travel times. For the conventional connections, 114 connections were excluded from further analysis based on the assumption that the travel times of the connection were too long compared to other available connections. The long travel times for these services were accompanied by stops at many intermediate stations. Therefore, it can be assumed that these services would not be used for transport along the entire route but primarily serve intermediate stops. The following conditions, therefore, applied to conventional services for inclusion in further analyses:

1) The travel time from the origin to the destination was less than 1 hour;
2) The original travel time by conventional rail before the introduction of HSR was faster than the time currently required to commute by car; or
3) The travel time for the given service was less than the average travel time, based on all relevant conventional services, plus a standard deviation, as expressed by the following equation:

$$T < \frac{1}{n}\sum_{i-1}^{n} ix_i + \sqrt{\frac{1}{N-1}\sum_{i=1}^{N} i(x_i - \underline{x})^2}$$

where T is the travel time, n/N is the number of conventional services on the given metropolitan-urban route, and x is the travel time on the nth service.

The change in the accessibility of metropolitan cities through HSR was measured based on two leading indicators: travel times and the frequency offered. These indicators for HSR were compared with the operation of conventional trains before the construction of HSR. As a result, the benefits of HSR in terms of time availability can be described. Travel times on high-speed lines were primarily calculated between HSR stations. When there was more than one HSR station in a metropolitan city, the travel time was calculated for the more centrally located station (e.g., in Milan: Milano Centrale was considered rather than Milano Rogoredo).

Travel times were calculated similarly for conventional connections. Time was calculated between the central station at the origin (an intermediate city) and the central station at the destination (a metropolitan city). Although the authors acknowledge the importance of the "first and last miles" to the total travel time, these were not included in the accessibility analyses for several reasons. The first and last miles are the equivalent of door-to-door transportation (Monzón *et al.*, 2016), typically done by road. However, this mode of transport was not investigated in this research. The second reason is that the research only dealt with rail transport; passengers must travel to a rail station in both cases. The general overview of city pairs with essential characteristics is presented in Table 1.

Table 1. Individual characteristics of metropolis-intermediate city connections

Origin metropolis	Destination	HSR opening year	Time-table source	Popu-lation (k.)	Station location	Distance (km)		Frequency		Travel time (min.)		Travel time (max.)		Travel time (avg.)	
						HSR	C-H	HSR	C-H	HSR	C-H	HSR	C-H	HSR	C-H
Milano	Reggio Emilia	2008	2005	161	P	151	157	27	20	40	83	53	112	48	99
	Bologna	2008	2005	371	C	215	219	51	32	59	105	77	144	67	117
	Brescia	2007	2005	190	C	83	83	33	24	38	50	48	64	39	52
	Desenzano del Garda	2007	2005	27	L	111	111	16	30	53	68	53	84	53	76
	Peschiera del Garda	2007	2005	10	L	125	125	17	31	57	70	69	94	60	85
Madrid	Guadalajara-Yebes	2003	2000	85	P	64	54	9	13	23	31	27	42	25	35
	Calatayud	2003	2000	21	L	221	242	9	7	56	127	76	146	65	135
	Cuenca Fernando Zóbel	2010	2005	55	P	189	201	15	3	52	146	70	161	62	151
	Ciudad Real	1992	1987	74	L	171	176	15	4	51	148	62	161	53	152
	Toledo	2005	2000	82	L	75	99	15	7	31	60	33	77	33	67
	Segovia	2007	2005	55	P	68	108	28	7	27	116	32	129	29	122
	Valladolid	2007	2005	312	C	180	250	31	14	54	144	78	161	64	150
Barcelona	Camp de Taragona	2008	2005	131	P	95	93	26	39	32	48	42	71	35	56
	Lleida	2008	2005	135	C	174	150	25	13	58	119	82	152	66	137
	Girona	2013	2010	94	C	95	102	15	22	40	82	41	96	41	88
	Figueres Vilafant	2013	2010	46	L	129	143	15	13	55	112	58	125	56	114
Paris	Lille	1993	1987	229	C	237	258	21	11	59	119	77	133	62	126
	Reims	2007	2005	179	C	147	173	14*	8	39	93	46	98	44	95
	Le Mans	1990	1987	142	C	202	211	7	22	63	99	64	138	63	112
	Vendome	1990	1987	17	P	162	-	12	-	45	-	52	-	50	-

Origin metropolis	Destination	HSR opening year	Time-table source	Popu-lation (k.)	Station location	Distance (km)		Frequency		Travel time (min.)		Travel time (max.)		Travel time (avg.)	
						HSR	C-H	HSR	C-H	HSR	C-H	HSR	C-H	HSR	C-H
Lyon	Valence TGV	1994	1987	95	P	104	105	17	19	36	50	47	72	40	57
	Le Creusot	1983	1978	23	P	129	-	7	-	42	-	50	-	45	-
	Avignon	1994	1987	90	L	234	230	15	15	63	115	82	151	70	125
Berlin	Wolfsburg	1998	1995	121	C	183	?	29	4	63	162	87	162	75	162
Frankfurt	Limburg	2002	2000	34	C	70	70	12	13	30	61	37	67	33	67
	Montabaur	2002	-	12	L	92	-	12	-	41	-	50	-	45	-
	Bonn/Siegburg	2002	2000	325	P	155	197	14	17	52	113	71	114	62	113
London	Ashford	2003	2000	67	C	90	90	46	31	30	65	44	84	39	73
	Folkestone	2003	2000	51	C	112	113	21	24	53	89	63	101	55	93
	Dover	2003	2000	41	C	124	124	21	44	64	99	74	119	66	108
	Canterbury	2003	2000	55	C	112	113	20	37	52	83	60	109	57	92
	Ramsgate	2003	2000	41	C	140	128	20	25	71	104	81	119	76	112
Amsterdam	Breda	2007	2005	173	C	117	132	50	31	67	118	72	121	68	121
Brussels	Liege	2002	2000	194	L	105	103	42	19	46	80	65	80	59	80

Note: C - central, L - lateral, P - peripheral[1], C-H - conventional-historical

Source: The European Rail Timetable (2019 and 1978, 1987, 1995, 2000, 2005, 2010), European Union, 1995-2023, own work.

[1] HSR station location characteristics: central, lateral (by the city's urban continuum limits) and peripheral (outside and separated from the city's urban continuum) (Mohíno *et al.*, 2018).

4. CHANGE FROM CONVENTIONAL TO HIGH-SPEED TRAIN

In this section, the research results are presented. The individual transport markets linked to each of the selected metropolitan areas are considered individually for each metropolitan area, for which the relationship with the relevant regional terminals is assessed in aggregate. Relevant transport markets are characterised in Table 1.

The first case focuses on the Spanish metropolises of Madrid and Barcelona (cases 1 and 2 in Fig. 2). Regarding Madrid, the introduction of HSR increased the frequency to all selected terminals except Guadalajara, where more conventional connections were operated than high-speed connections. Regarding the total frequency, Madrid saw them more than double (an increase of 122%). The average travel time on HSR was 55% below the average on conventional services, considered the fastest conventional service one quarter (26%) below the original time. In Barcelona, the situation was somewhat different since of the four routes studied, only two, i.e., to Girona and Lleida, saw an increase in connections due to the introduction of HSR. In particular, the number of conventional connections to Camp de Tarragona was initially at a substantial level. As a result, the number of high-speed connections on the routes examined for Barcelona reached only 93% of the original number of conventional connections. However, substantial time savings were recorded, with the average travel time being reduced by 42% of the original travel time and the fastest service by a third (33%) of the original time.

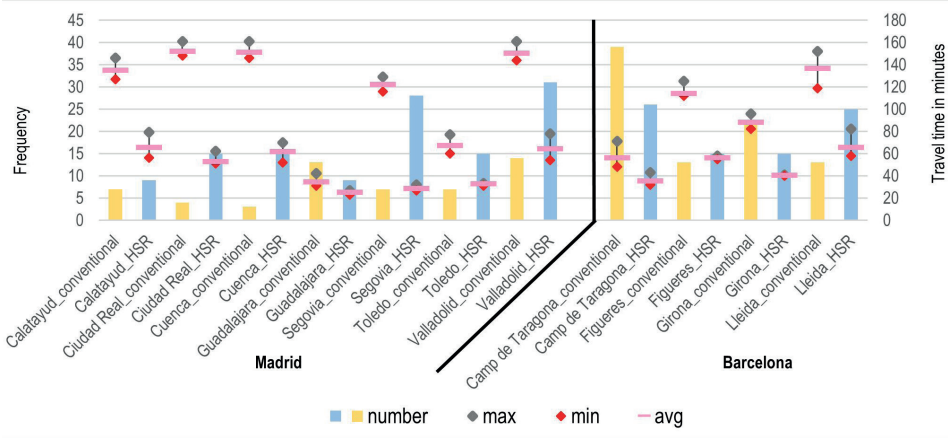

Fig. 2. Metropolitan cases 1 and 2: Madrid and Barcelona – frequency and travel time range – comparison of HSR and conventional trains

Cases 3, 4, and 5 in Fig. 3 present the results for the metropolitan core–intermediate city pairs linked to crucial international high-speed links, namely London, Brussels, and Amsterdam. In the case of London, five routes were considered, of which only one, Ashford, saw an increase in connections due to the introduction of HSR (46 HSR/ 31 conv.). In contrast, the number of HSR connections did not reach the conventional numbers for the others. Overall, the number of HSR services was 80% of the original conventional services. However, average travel times fell by less than half (43%) of the original travel times. One connection was always considered in the case of the other two metropolises shown in Fig. 3. On the Brussels–Liege route, the introduction of HSR more than doubled the frequency (an increase of 121%) and reduced the average travel time by about a quarter (27%). On the Amsterdam–Breda route, HSR increased services by 61% and reduced the average travel time by less than half (44%).

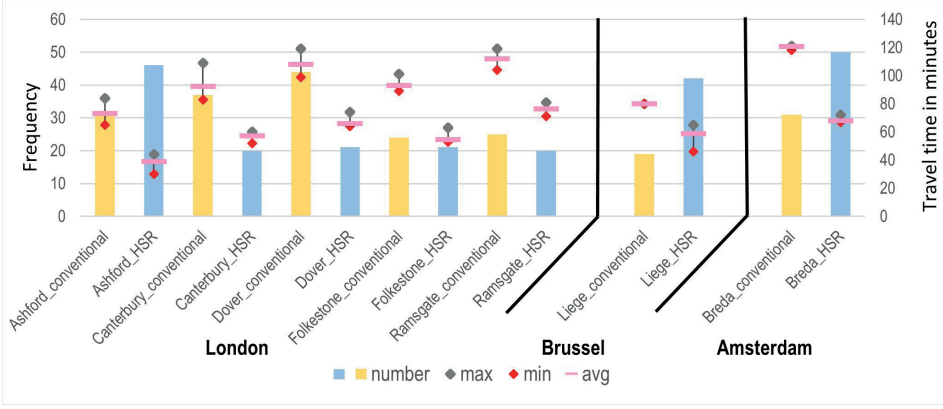

Fig. 3. Metropolitan cases 3, 4, and 5: London, Brussels, and Amsterdam – frequency and travel time range – comparison of HSR and conventional trains

Cases 6 and 7 in Fig. 4 show the results for two French metropolises, Paris and Lyon, which are also connected by a critical long-distance HSR artery linking these two major French metropolises. It is worth mentioning that these French cases have a very long period of impact. These lines were introduced in the previous century (except for Paris–Reims) and cover the oldest HSR connection on the crucial line between Paris and Lyon, here connected to Lyon: Le Creusot, where HSR was introduced in 1981. In the case of Paris, four linkages with HSR services were considered, with the line to Le Mans recording only 32% of the original number of conventional services. The services to Lille and Reims saw substantial increases, and the one to Vendome saw the introduction of entirely new services. Overall, introducing HSR increased services by a third (32%) while halving the

average travel time (a reduction of 51%). In the case of Lyon, three services were considered: the line to Avignon, where the introduction of HSR did not change the number of services; the line to Valence, where the number of HSR services was lower than the original conventional services; and the line to Le Creusot, where completely new services were introduced. Overall, the number of services increased by 15%, and the average travel time fell by less than a half (40%). Even the fastest service fell by less than three quarters to 28% of the original conventional time.

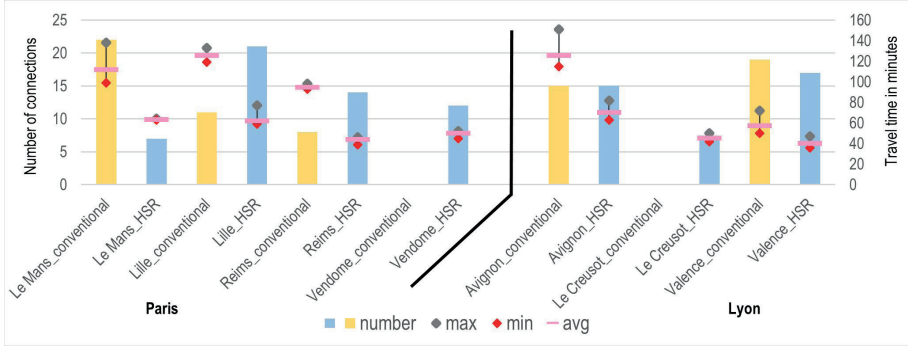

Fig. 4. Metropolitan cases 6 and 7: Paris and Lyon – frequency and travel time range – comparison of HSR and conventional trains

The last of the graphs presenting the results for individual sessions (cases 8, 9, and 10 in Fig. 5) shows the results for the metropolitan areas of Milan, Berlin, and Frankfurt. In the case of Milan, five linkages with HSR services were examined, three of which showed a substantial increase in the frequency, namely to Bologna, Brescia, and Reggio Emilia. The lines to Desenzano del Garda and Peschiera del Garda showed fewer HSR connections than conventional ones. However, it should be noted that these two services are essentially tourist destinations used by many Milanese for weekend holidays, for which conventional services appear sufficient, given the short distances involved. The average travel time for Milan-bound services fell by about a third (37%); even the fastest travel time fell by less than a quarter (24%) of the original conventional travel time. In the case of Berlin, one connection to Wolfsburg was considered, where the frequency increased substantially to more than seven times the original (an increase of 625%), and the average travel time fell by about a half (54%). The last metropolitan area examined was Frankfurt am Main, where three services were considered, one of which, to Montabaur, involved the introduction of entirely new services, while the remaining two, to Bonn and Limburg, had slightly fewer high-speed services than conventional services, with an overall increase of 27% in the number of services and a fall in average travel times by less than a half (49%).

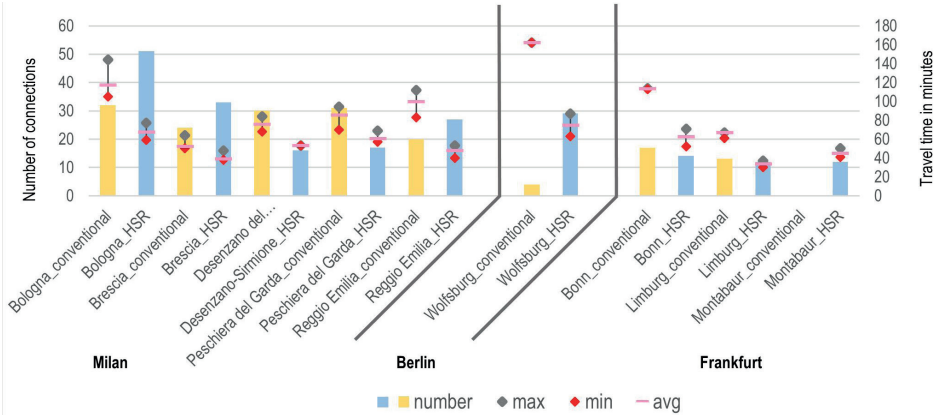

Fig. 5. Metropolitan cases 8, 9 and 10: Milano, Berlin, and Frankfurt – frequency and travel time range – comparison of HSR and conventional trains

Source figures 2 to 5: European Rail Timetable, 2019; own work.

In summary (Fig. 6), the frequency increased by 17% due to the construction and introduction of HSR. Another benefit to the routes studied on metropolitan core–intermediate city relationships was the average time savings of 43%. Therefore, these routes do not reflect long-distance traffic but everyday commuter traffic. It should be added that the routes studied range from 64 to 237 km, and the average distance on all routes studied was 137 km. The average reduction of 43% in commuting time to or from a metropolitan core is a relatively substantial benefit. Especially since it is on shorter distances, time savings are more difficult to achieve. However, at these distances, the most massive traffic flows occur. In contrast, long-distance transport may be more subject to seasonal influences and may reflect other characteristics according to the metropolitan areas it connects.

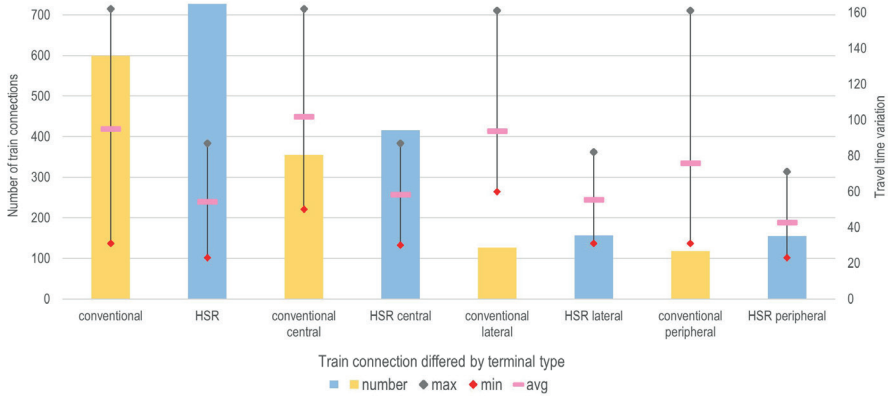

Fig. 6. Summary comparison of HSR and conventional lines

Source: European Rail Timetable (2019); own work.

In the 34 pairs of metropolitan cores with intermediate cities representing 10 metropolitan regions in 7 different countries, which are associated with different institutional approaches to the planning and construction of HSR lines, it can be observed that the benefits varied somewhat according to the examples analysed. Although the overall impact shown in Fig. 6 is substantial, it should be noted that it depends very much on the specific situation of each link analysed. Based on the analysis, these connections can be divided into several categories according to the initial conditions of each pair of a metropolitan core and an intermediate city (see Table 2).

The possible role of the HSR introduction:

A. New connections: This is an essential category where the introduction of HSR through a completely new route brought the possibility of a connection for a new location that did not have a direct rail connection in the past (Frankfurt–Montabaur, Lyon–Le Creusot, Paris–Vendome). This category is based on the exclusive position of HSR connections, for which there is no competition in the form of existing conventional rail links.

B. Marginalisation of the conventional connection offer: This category represents situations where HSR connections substantially increase connection frequency. This way they represent an entirely new role in offering rail connections for which conventional rail is not competitive in terms of either frequency or travel time. Therefore, the conventional part of the rail links was marginalised, and it can be assumed that the main objective of these conventional links was to serve additional intermediate stops of even lesser importance. Examples of such connections include Berlin–Wolfsburg, Madrid–Cuenca, Madrid–Segovia, Madrid–Ciudad Real, Madrid–Valladolid, Brussels–Liege, Madrid–Toledo. There was a considerable increase in service for these pairs, at least roughly double the frequency compared to the original conventional railway.

C. Substantial predominance of HSR connections: In this category, HSR connections substantially increased the serviceability of a given intermediate city. However, it cannot be unequivocally said that this was such a fundamental marginalisation of conventional rail as in the previous case. Nonetheless, it is possible to support the claim that HSR also brought a substantial change in speed and service. Examples of such connections include Barcelona–Lleida, and Paris–Lille. Paris–Reims, Amsterdam–Breda, Milan–Bologna, London–Ashford, Milan–Brescia, and Milan–Reggio Emilia. In this category, there was an increase in services through the introduction of HSR.

D. Balancing the conventional connection supply: This category represents situations where HSR connections took over a substantial part of the transport supply and had an overall share of around half of the number of rail connections. There was also a certain complementarity of supply, but with much more substantial effects on the overall structure of the services offered. Although conventional rail links were probably not equivalent, they were still substitute products, although conventional rail links were probably not equivalent but still a substitute product.

Examples of such connections include Madrid–Calatayud, Barcelona–Figueres, Lyon–Avignon, Frankfurt–Limburg, Lyon–Valence, London–Folkestone, Frankfurt–Bonn, and London–Ramsgate. In this category, HSR connections showed service levels between 70% and 100% of the original conventional service.

E. Supplementing the conventional connection supply: This category represents situations where conventional railways offered above-standard connection frequencies, so HSR connections were only a particular supplement to transport services. Their target group was only a selected minority segment. The existing conventional railways continued to be used widely. This situation naturally presupposes the parallel operation of conventional and HSR connections. Examples include the heavily used Madrid–Guadalajara, Barcelona–Girona, Barcelona–Camp de Tarragona, Milan–Peschiera del Garda, London–Canterbury, Milan–Desenzano del Garda, London–Dover, and Paris–Le Mans lines. HSR connections showed service levels at less than 70% of the original conventional service in this category. It is clear from the above list that the Milan connections were widespread destinations used extensively for suburban tourism by the Milanese, while the Barcelona and London connections were essential destinations resulting from work commutes. Nevertheless, even in these cases, HSR brought entirely new quality in substantially reduced travel times.

Table 2. Categories of connections with frequency change (in %)

type	route	HSR connections	change	type	route	HSR connections	change
A	Frankfurt – Montabaur	12	-	C	Milano – Reggio Emilia	47	135.00
A	Lyon – Le Creusot	7	-	D	Madrid – Calatayud	16	128.57
A	Paris – Vendome	12	-	D	Barcelona – Figueres	28	115.38
B	Berlin – Wolfsburg	33	725.00	D	Lyon – Avignon	30	100.00
B	Madrid – Cuenca	18	500.00	D	Frankfurt – Limburg	25	92.31
B	Madrid – Segovia	35	400.00	D	Lyon – Valence	36	89.47
B	Madrid – Ciudad Real	19	375.00	D	London – Folkestone	45	87.50
B	Madrid – Valladolid	45	221.43	D	Frankfurt – Bonn	31	82.35
B	Brussels – Liege	61	221.05	D	London – Ramsgate	45	80.00

Table 2 (cont.)

type	route	HSR connections	change	type	route	HSR connections	change
B	Madrid – Toledo	22	214.29	E	Madrid – Guadalajara	22	69.23
B	Barcelona – Lleida	38	192.31	E	Barcelona – Girona	37	68.18
B	Paris – Lille	32	190.91	E	Barcelona – Camp de Taragona	65	66.67
C	Paris – Reims	22	175.00	E	Milano – Peschiera del Garda	48	54.84
C	Amsterdam – Breda	81	161.29	E	London – Canterbury	57	54.05
C	Milano – Bologna	83	159.38	E	Milano – Desenzano del Garda	30	53.33
C	London – Ashford	77	148.39	E	London – Dover	65	47.73
C	Milano – Brescia	57	137.50	E	Paris – Le Mans	29	31.82

Source: The European Rail Timetable (2019 and 1978, 1987, 1995, 2000, 2005, 2010), own work.

The above typology of the identified intra-metropolitan systems of HSR connections cannot, by its nature, cover all institutional, geographical, technical, and socio-economic aspects. Therefore, some of the links analysed are on the edge between two categories, and it could be somewhat problematic to classify them into one of the categories strictly. Examples include Madrid–Calatayud balancing categories C and D with an increase in services of 29%, and the Madrid–Guadalajara line on the border between categories D and E with HSR services at 69% of the original conventional level.

5. THE FREQUENCY ESTIMATION MODEL

The result of the analysis of the frequency and time changes determined by the introduction of the high-speed connection is an important prerequisite for the planning of possible further construction of high-speed lines in the future, and especially for planning the prioritisation and efficiency of regional high-speed terminals in medium-sized cities. The following frequency estimation model represents the transformation of the results into a potentially applicable planning

framework. Thus, the frequency estimation model is proposed to estimate a potentially optimal HSR operational frequency for countries developing HSR networks based on the currently developed European HSR systems. As presented in Section 4, according to several scenarios for the role of HSR inside metropolitan regions mentioned above.

Simple gravity model introduced by Anderson (1979) and applied primarily to identify trade flows is in the beginning of the study. However, the model has been applied to transport issues. Its underlying variation reflects economic or population importance and geographical proximity measured by time or distance. The basic gravity model for transport flows is determined as follows:

$$F = G\left(\frac{POPi * POPj}{Dij}\right)$$

where F is the transport flow, G is the constant, $POPi$ is the population of city i, $POPj$ is the population of city j, and Dij is the distance between cities i and j.

The Frequency estimation model comes from the simple gravity model. Frequency is used as a proxy for transport flow, while there is no data available on the number of passengers covering historical milestones from the years when HSR was launched on the routes (starting in 1978 and finishing in 2010). The estimated relation between the metropolitan core and relevant intermediate city as the assumption for the frequency is expressed as ERP_n … which is the estimated relation power of city pair on the specific transport market or route[2] in the analysed sample. In the next step, the model was augmented to reflect more variables covering the conditions on the route before the introduction of HSR. As a result, the standard combination of traditional variables was used in the model, coming from the dataset mentioned in section 3 Data and methods.

First, the size of the market expressed as POP_t …is a sum of the metropolitan core and the relevant intermediate city population because it reflects the size of such a transport market, and it is raised to the power of two to emphasize the strength of these two cities. The second traditional variable is the distance between the metropolitan core and the intermediate city expressed as D… which is the rail route distance of a given train between the metropolitan core and the relevant intermediate city in kilometres.

Further, the model was augmented with variables reflecting starting conditions and other principal contextual factors on the route as a next step. As the first substantial variable, the travel time of a given rail connection was used and expressed as T_r … which is the travel time by a train on the route between the

[2] All of the route travel times and distances are measured between the metropolitan core central station and relevant intermediate city station.

metropolitan core and the relevant city of a train connection. This travel time enables one to identify the potential benefits achieved by launching high-speed trains on a given transport market or rather a given route for end-users or commuters. As the next step, the direct train's slowest original conventional travel time was used and expressed as a T_{max}… which is the maximum conventional train time before high-speed introduction on the route between the metropolitan cores and the relevant city. This variable enables the authors to assess the range of potential benefits for passengers because the slower the original conventional rail was, the higher the potential benefit of high-speed introduction. The reason for putting this variable to the numerator is that it potentially increases the benefits expressed in our model as frequency, reflecting the reaction of demand of passengers.

From the two variables mentioned above, the variable $T_{max\text{-}dif}$ was derived, which is the ratio of the travel time of a train (both conventional or high-speed) connection compared to the maximum travel time by conventional train between a metropolitan core and a relevant city. This variable enables one to identify the range of individual benefits of each train connection faster than the slowest one. It means that the faster the train connection, the lower the ratio is, and that is the reason to put this variable to the denominator, because faster trains increase the potential benefit. The last variable reflecting the context and the significance of the change achieved by the introduction of high-speed connection is variable $T_{train\text{-}road}$ … which is the ratio of the travel time of a train (both conventional or high-speed) connection compared to the travel time by car between the metropolitan core and a relevant city. It is defined as a ratio of travel time by a train connection divided by the travel time by car. In other words, the slower the original train connections, the greater the potential benefit. Thus, this variable is reflected in the numerator. To achieve the balance of the model in accordance with the substance of used variables in the numerator (meaning T_{max} and $T_{train\text{-}road}$) based on travel time, both time-derived variables used in the denominator by two (meaning T_r and $T_{max\text{-}dif}$) were raised.

The last variable used in the model reflects the balance of size or power of a metropolitan core and an intermediate city, because the smaller the intermediate city is, the lower the motivation to operate the HSR stop there. It is defined as POP_{dif}… which is the share of the relevant intermediate city population to the metropolitan core population. It means that the smaller the intermediate city is, potentially lower the benefits are. Thus, it decreases the motivation for higher frequency. This variable is consistently put in the numerator because it corrects the market size as the abovementioned total.

Finally, the model according to the logic above reflects the frequency change in the new state compared to the original state with a conventional rail link, while frequency is considered as a proxy for potential benefits from the introduction of the HSR connection.

The formula for the estimated relation power ERP_n of the city pair on the specific route is expressed as:

$$ERP_n^{hsr} = \sum_{r_1}^{r_n} \left(\frac{POP_t^2 * POP_{dif} * T_{\max} * T_{train-road}}{D * T_r^2 * T_{\max-dif}^2} \right)$$

The results of the equation were normalised by range (Min-Max Normalisation) according to the following equation:

$$ERP_{n-normalised}^{hsr} = \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

Thus, the resulting values of $ERP_{n\text{-}normalised}^{hsr}$ … lie in the interval {0,1}. The HSR frequency estimation formula is based on an estimated linear trend capturing the relationship between the actual number of HSR connections and Estimated Relation Power (ERP), see Fig. 7, which can be defined as a standard equation of the line:

$$y = a * x + b$$

where coefficient $a = 68.493$, variable $x = ERP$, and constant $b = 9.048$

The frequency estimation model equity:

$$F_E = 68.493 * ERP_{n\text{-}normalised}^{hsr} + 9.048$$

where F_E is the frequency estimation of HSR connections on the specific route[3]. The standard deviation in our model achieved 15.07, but it varies from less than two to twenty in different groups. The model was verified using a total sample of 1,464 connections included in the analysed dataset.

The operational HSR frequency of every 34 metropolitan core–intermediate city pairs was compared in Fig. 7 with the estimated frequency gained by the model formula. The presented verified results show the intersperse by the linear regression curve–the model defined above results in a solid correlation of 0.647.

Figure 7 presents the regression of estimated relation power ERP on the X axis and the city pairs operational HSR frequencies on the Y axis. Because of the high density of points representing city pairs between the value range of 0.00-0.05 the diagram was split and zoomed to two appropriate parts.

[3] All of the route travel times and distances are measeured between the metropolitan core central station and relevant intermediate city station.

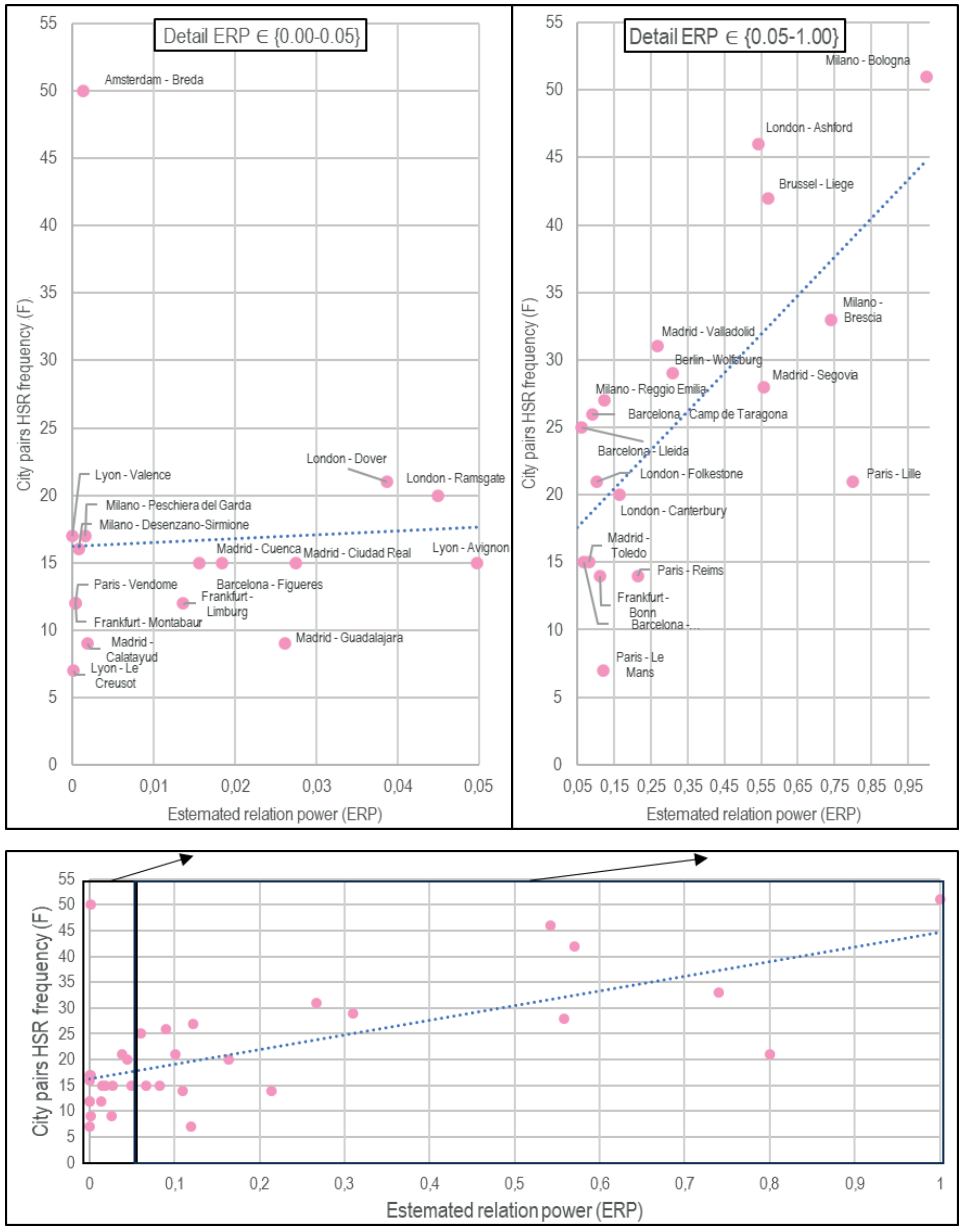

Fig. 7. Estimated relation power verified on operated HSR frequency
Source: European Rail Timetable (2019); own work.

The results from the first part of the paper and the frequency estimation model were synthesised. The correlation between the actual operated HSR frequencies *F*

and estimated HSR frequencies F_E differs based on the category of HSR role. As represented in Fig. 8, the correlation value decreases from category A to E as the significance of the HSR role decreases. The correlation value of category A equals R=0.995, category B (R=0.881), category C (R=0.442), category D (R=0.258), and category E (R=0.093). The general correlation value of all HSR routes equals R=0.647.

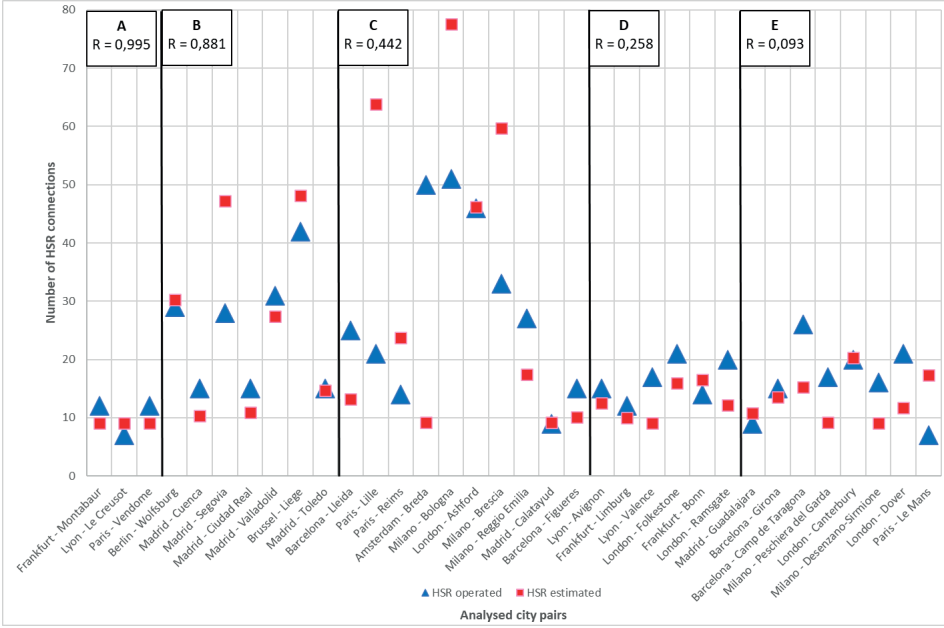

Fig. 8. Correlation between real operated HSR frequency and HSR frequency estimation model

Source: own work.

In the analysed sample, two extreme values appear, and both belong to category C. The exclusion of extreme values is a standard method of analysed sample normalisation. The first extreme is the route Paris–Lille, where 21 HSR connections are operated, but 64 HSR connections are estimated by the model. The number of estimated connections is strongly influenced by the strength of a relationship and the long operating distance, where HSR dominates compared to conventional trains. The correlation of the category would increase by about 0.157 to R=0.579, and the general value would increase by about 0.055 to R=0.712. The second extreme represents the route Amsterdam–Breda, where 50 HSR connections are operated, but only 9 HSR connections are estimated by the model. The correlation of the category would increase by about 0.272 to R=0.714, and the general value would increase by about 0.133 to 0.780. In total, the category C correlation value would increase to R=0.855 and the general value R=0.852.

6. CONCLUSION

This paper challenged the goal to seek a transferable operational experience for countries developing HSR networks based on the currently developed European HSR operational models. That is why the study offers the frequency estimation model formula as a tool for an estimation potentially optimal HSR operational frequency based on the analysis of the sample of 10 European metropolitan regions, more concretely 34 metropolitan core-intermediate city pairs. The paper focuses on a specific segment of HSR network operation: HSR commuting delimited by 1 hour of the operational distance between the metropolitan core and the intermediate city.

The key step to derive the frequency estimation model was to estimate the relation power *ERP* between the metropolitan cores and intermediate cities, where HSR connections are operated. To reach this estimation the basic gravity model was modified and traditional variables as population, distance, travel time and their variations were used.

The estimated linear relation between the *ERP* and real operated HSR frequency *F* on analysed city pairs brought the necessary coefficients to set the formula. It results to Frequency estimation formula F_E, which estimates the potential frequency of HSR services on selected relation between metropolitan core and intermediate city delimited by 1h of travel distance.

The potential linear relation between *ERP* and *F* based on analysed sample prove the strong correlation R=0.647. In case of extremes elimination, the correlation increases to R=0.852. However, to keep results transparent, the study is presented with extreme values and points to them. The correlation of results variates based on a different role of HSR operation in intermediate cities stations from 0.995 to 0.093 and from that point of view the universal application of Frequency estimation formula without considering the purpose of HSR introduction seems not probable.

The secondary research results bring a partial explanation of such a range of the equation result, which refers to different role of HSR implementation. The supply of rail connections increased substantially by an average of 17%. Above all, however, there was a substantial qualitative change in transport speed. It showed savings of up to 43% in travel time on average, while there were still significant savings of around 25% on the fastest conventional connections. These results are crucial to creating a long-term strategy to motivate people to travel by public transport within a metropolitan area, especially in competition with car transport.

Subjective perceptions of between a quarter and almost a half of the previous travel time play a substantial role in individual decisions about mode choice. This context also raises a follow-up research question that was not the focus of this

paper: research on the change in the proportion of travel time by train relative to travel time by car. However, research into historical car travel times from the past century would be somewhat problematic, whereas analysis of train timetables is reasonably reliable in this respect. Of course, the competitive advantage that HSR brings concerning conventional rail and cars is that it frees up existing arterial capacity (on rails, conditional on the parallel operation of conventional and HSR lines). In the case of car transport, substantially higher travel times can be expected in after-peak periods within metropolitan areas precisely because of increasing congestion.

The benefits of HSR relative to existing rail are only sometimes entirely clear in both aspects analysed: frequency and travel time. Therefore, it is always necessary to keep in mind the different starting conditions of each planned HSR project. For this reason, this research presented a typology of five HSR service commuter systems. The categorisation depend on whether the HSR introduced entirely new rail links, brought a complement to existing conventional rail links, created a balanced supply of conventional and HSR links, showed substantial predominance, or marginalised conventional connections (which were more likely to serve even smaller intermediate stops than direct links between the pairs of metropolitan cores under study and their associated intermediate cities).

This typology of identified intra-metropolitan systems of HSR services cannot, by its nature, cover all the institutional, geographical, technical, and socio-economic aspects that influenced the ultimate effectiveness and sensibility of implementing HSR. Only some of the analysed pairs of metropolitan cores and intermediate cities could be strictly classified into the defined categories, as some are typologically located at their imaginary interface. However, this research provides new insights, especially in the somewhat overlooked area of intra-metropolitan transport services within HSR. Indeed, the usual emphasis is on analysing what HSR brings as a link between two or more metropolitan areas, emphasising its impact on the centres of these metropolitan areas. This fact is ultimately the basis for the economic appraisal of HSR planning. However, the analysis of the impact on minor terminals included in the HSR network is a somewhat under-appreciated topic that can make an essential contribution to the possibility of a more comprehensive assessment of the benefits of HSR. Therefore, these findings can also contribute to an accurate assessment of the benefits and costs of future planned developments or projects.

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FINANCIAL DETERMINANTS OF MODE SUBSTITUTION IN RESIDENTS' TRAVEL BEHAVIOUR: A CASE STUDY OF PUBLIC BIKE-SHARING IN LODZ, POLAND

Abstract. Bike-sharing networks have achieved considerable success in many cities worldwide, gaining a growing number of supporters for this mode of transportation. While the existing literature covers various aspects related to bike-sharing, the exploration of the relationship between these networks and the financial benefits for residents when transitioning to cycling has been somewhat limited. Therefore, the main objective of our article is to identify the factors influencing urban residents' decisions to switch to cycling and to understand the significance of financial considerations in shaping changes in travel behaviour.

We assessed the perceived affordability of bike-sharing services by measuring respondent satisfaction (via Computer Assisted Personal Interviews – CAPI) with the rental prices of city bicycles. To examine the relationships between variables, we employed statistical tests, including the Fisher test, the chi-square test of independence, and the Mann-Whitney test. Our research findings confirmed that replacing public transportation with bicycles has the most substantial impact, while substituting car trips has a relatively minor effect. Furthermore, our analysis revealed statistically significant associations between price satisfaction and the decision to abandon car travel in favour of cycling, as well as the motivation to save costs and substituting walking and public transport with bicycle travel.

Key words: bike-sharing, travel behaviour, financial and economical determinants, modal substitution.

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1. INTRODUCTION

The modal substitution of car travel with environmentally friendly low-carbon mobility options represents a pivotal strategy for transitioning towards sustainable urban mobility (Becker and Rudolf, 2018; Zhang *et al.*, 2022). A key expectation associated with public bike-sharing systems is their potential to redirect existing car journeys towards more sustainable modes of transportation, such as bicycles (Fishman *et al.*, 2014; Lu *et al.*, 2018; Shaheen *et al.*, 2016). However, previous research has suggested that shared bikes have not been entirely effective in displacing car travel (Johansson *et al.*, 2019; Fishman *et al.*, 2014; Bieliński *et al.*, 2021). Our understanding of the factors that drive modal substitution remains incomplete (Javaid *et al.*, 2020; Guo and Zhang, 2021; Chen *et al.*, 2022a). Thus, this paper aims to uncover the patterns of modal substitution brought by urban cycling and to underscore the significance of financial considerations in influencing the travel behaviour of urban residents. In our study, we consider modal substitution as potentially permanent, frequent, or occasional and encompassing the replacement of cars, public transport, and pedestrian journeys with shared bicycles.

Our emphasis on financial factors stems from the impact of bicycle rental fees on the adoption of this mobility option in urban settings, a phenomenon well-documented in numerous studies (Ricci, 2015; Podgórniak-Krzykacz *et al.*, 2022; Ji, 2023). The primary contribution of this research to the field lies in its focused investigation into the role of financial factors in shaping modal substitution. By examining perceived cost savings in transportation, the financial accessibility of bike-sharing services, and the income of users, we introduce a novel dimension to the discourse, shedding light on the economic motivations underpinning modal substitution decisions.

The findings of this study could offer valuable insights for policymakers and urban planners seeking to promote sustainable urban mobility and reduce reliance on private vehicles, especially in light of ongoing global efforts to address climate change and urban sustainability.

The analyses conducted in this article pertain to the city of Lodz in Poland. Poland has emerged as a leader among Central and Eastern European countries in the development of shared mobility systems, particularly bike-sharing systems (Kuźma *et al.*, 2022). Lodz, a central Polish city, offers an intriguing context to explore the dynamics of urban mobility. The city's flat topography, coupled with an expanding network of bike lanes and cyclist-friendly infrastructure, creates an ideal setting for bike-sharing activities. Lodz boasts a diverse transportation system, with two traffic peaks, one around 9 a.m. and another at 5 p.m., followed by a gradual decline in travel until 11 a.m. (Borowska-Stefańska *et al.*, 2021). This pattern suggests significant potential for bike-sharing to play a pivotal role in urban mobility and alleviate transportation congestion.

The bike-sharing system in Lodz was inaugurated in 2016, with Nextbike serving as its operator at the time. In its inaugural year, the system achieved a notable success, and in the subsequent years, rental numbers remained relatively stable. Between 2016 and 2019, approximately 1.5 million bike rentals were recorded annually, accompanied by a concurrent doubling of registered users, from 66,000 to 130,000 (Rowerowa Łódź, 2022).

Our survey was conducted among 296 users of the bike-sharing system in Lodz in 2019. This study examines three financial predictors influencing changes in citizens' travel behaviour following the introduction of a bike-sharing service: the role of transport cost savings as a motivation for using bike-sharing services, the perceived financial accessibility of the bike-sharing service, and the income levels of users. The financial conditions for utilising the bike-sharing system in Lodz were favourable for users making short trips, as the first 20 minutes of bike usage were free, and the high density of bike stations, particularly in the city centre and its immediate surroundings (Borowska-Stefańska *et al.*, 2020), which facilitated covering short distances at no cost. As such, our study aims to investigate whether financial factors influenced the substitution of other transportation modes with shared bicycles.

We sought answers to the following research questions:

1. Does the availability of the public bicycle system in Lodz lead to modal substitution where respondents opt for shared bicycles over other means of urban transportation?
2. Is there a correlation between the significance of financial factors for using public bicycles and the frequency of substituting other modes of transportation with bicycles?

The structure of this article is as follows. The following section presents a literature review examining the impact of bike-sharing service availability on residents' travel behaviour, along with the findings of previous studies regarding the determinants of such changes, including financial aspects. The methodology and results sections follow, and the article concludes with a discussion and summary.

2. LITERATURE REVIEW

Shared mobility has become an integral part of urban landscapes worldwide, offering travellers short-term access to various transportation modes, including motor vehicles, bicycles, and scooters, tailored to their specific needs. Bike-sharing represents a prime example of the sharing economy paradigm, offering an innovative solution to transportation challenges (Pawłowska, 2019). Bike-sharing programs have been successfully introduced and implemented in numerous cities globally, serving as policy instruments to mitigate greenhouse gas emissions, alleviate

traffic congestion, and promote physical activity. They have effectively bridged gaps in existing public transportation networks (Shaheen and Chan, 2016). Empirical evidence underscores the substantial positive externalities associated with bike-sharing programs. These programs offer urban residents a convenient and time-efficient mode of travel (Maas *et al.*, 2021) while reducing traffic, lowering energy consumption, minimising harmful emissions, enhancing public health, and stimulating economic growth (Chen *et al.*, 2022b). Bike-sharing holds the potential to play a pivotal role in urban transportation development, providing valuable insights for shaping urban transportation policies (Qiu and He, 2018). Nevertheless, transitioning travel behaviour away from automobiles and towards more sustainable alternatives, such as cycling, has proven to be a formidable challenge. Historical engineering-focused solutions to transportation issues during the 1960s to the 1990s marginalised cycling to the extent that utility trips in the United Kingdom plummeted from 13% in 1952 to around 1% by 1972 (Watson and Shove, 2008).

However, in many cities worldwide, residents, authorities, and other stakeholders have embraced the positive outcomes associated with private or shared bicycles. The surging popularity of cycling serves as evidence that behavioural change is attainable, even in cases of limited or suboptimal infrastructure investments (Pucher *et al.*, 2011). Some research has investigated the transition from other modes of transport to shared bikes (Crisostomi *et al.*, 2015). On average, no significant change was observed when shifting from private cars (Midgley, 2011; Johansson *et al.*, 2019). However, residents more frequently switch from public transport (Jäppinen *et al.*, 2013), a phenomenon often attributed to cultural factors, where public transport is perceived as the least desirable option, offering inadequate service quality. López-Casasnovas (2009) estimated that in Barcelona, most bike-sharing users had previously relied on public transport, implying that bike-sharing has, to some extent, supplanted mass transit systems like buses and subways.

Conversely, Otero *et al.* (2018) demonstrated that, when accounting for control variables and spatial effects, the frequency of public transport use significantly correlated with the number of bike-sharing trips. This positive effect was observed for short and medium-distance trips, but no such relationship was found for long-distance journeys. These findings underscore the relevance of public transport frequency as a determinant of bike-sharing usage, an aspect deserving attention in urban planning (Otero *et al.*, 2018; Radzimski and Dzięcielski, 2021).

Recent developments have introduced unexpected shifts in travel behaviour. Abdullah *et al.* (2021) noted that travel behaviour worldwide underwent significant changes following the outbreak of the COVID-19 pandemic. Researchers confirmed a shift towards personal cars during lockdowns (Abdullah *et al.*, 2021; Ku *et al.*, 2021; Tan and Ma, 2021). Another study explored the spatiotemporal shift in bike-sharing patterns in Chicago during the pandemic, comparing them to other transportation modes. Generalised additive (mixed) models were employed

to identify relationships and non-linear time interactions between daily bike-sharing usage at the station level and various independent variables. The results revealed that stations located in areas with higher income levels experienced a decrease in bicycle use during the pandemic compared to the pre-pandemic period (Li *et al.*, 2021).

According to Campbell *et al.* (2016), research based on a preference survey and multinomial logit analysis suggests that transitioning from existing modes of transport to bike-sharing depends on factors such as travel distance, temperature, precipitation, and air quality. Another study underscores the key factors contributing to bike-sharing success, emphasising the importance of local government experience, well-planned infrastructure, and public education as essential pillars of effective bike-sharing systems (Kwiatkowski and Biegańska, 2021). Zhao and Li (2017) observed that individuals with middle and high incomes were more likely to opt for cars over bicycles, while those with lower incomes preferred buses. Personal attitudes also play a crucial role in mode choice, as individuals who prioritise cost-effective travel are more inclined to choose cycling. Rodriguez-Valencia *et al.* (2021) revealed a connection between experience with public bike-sharing and perceptions of it as a mode of transportation. Less experienced users were more motivated by rational reasons, such as cost savings and dissatisfaction with subpar public transport. In contrast, experienced cyclists linked their use of public bikes to their passion for this mode of transport. Fishman *et al.* (2013) emphasised the paramount importance placed on value for money by bike-share members, a primary motivation for their registration and utilisation of these programs.

Numerous studies have explored the benefits of bike-sharing (Shelat *et al.*, 2018; Nieuwenhuijsen and Rojas-Rueda, 2020; Chen *et al.*, 2022c; Zhi *et al.*, 2022). Otero *et al.* (2018) conducted a health impact assessment study to quantify the health risks and benefits of replacing car travel with the European Bike-Sharing System (BSS). The health benefits of physical activity outweighed the health risks posed by fatal road accidents and air pollution. The level of car travel substitution corresponded to an annual saving of €18 million, primarily due to reduced fatalities. The benefits of shared bikes can also be assessed from an economic perspective. Bullock *et al.* (2017) demonstrated the economic advantages of bike-sharing schemes in Dublin, showcasing individual benefits and public good outcomes.

However, research on the impact of public bicycling on citizens' transport behaviour and the importance of financial factors driving these changes in Central and Eastern European countries remains limited. Analyses of bike-sharing systems in this region underscore their dynamic development and strong user interest (Kuźma *et al.*, 2022). Poland, in particular, stands out with its average annual revenues from bike-sharing services, reaching €21 million in 2019, several times higher than neighbouring countries (Borowska-Stefańska *et al.*, 2020). The development of bike-sharing systems in Poland began in 2010 and proceeded at a rapid pace until the COVID-19 pandemic. During the pandemic, bike rentals in major Polish cities

dropped by almost 50% (Jędrzejewski, 2022). From 2020 to 2022, the shared bike market in Poland experienced renewed growth, with 79 bike-sharing systems operating in 2022, offering approximately 23,700 vehicles (Mobilne miasto, 2023).

In contrast to the prevalence of scooter-sharing systems in Polish cities, constituting 80% of the shared micro-mobility market, 95% of bike-sharing systems are government-owned (docked bike-sharing), with only 5% being commercial systems. Public bike systems in Poland are largely funded by cities, with development often facilitated by European Union funds (Dzięcielski *et al.*, 2020). Due to high maintenance costs, some Polish cities (e.g., Poznań, Olsztyn) have discontinued bike-sharing systems in recent years, while new systems continue to emerge. In 2024, the launch of the largest bike-sharing system in Poland, and the third-largest in Europe, is planned across 31 municipalities in the Górnośląsko-Zagłębiowska Metropolis. The system will include 7,000 bikes and approximately 1,000 stations, offering passengers using public transportation monthly passes the ability to rent bikes for free for up to 30 minutes a day (Metropolia GZM, 2023).

Research on public bicycling in Polish cities has focused on the performance of bike-sharing systems (Bieliński *et al.*, 2019), frequency of use, motivations and determinants of public bicycle use, including financial considerations (Podgórniak-Krzykacz and Trippner-Hrabi, 2021; Podgórniak-Krzykacz *et al.*, 2022), user evaluations (Macioszek *et al.*, 2020), or evaluations of specific application features (Pamuła and Gontar, 2017). However, the issue of modal substitution resulting from the introduction of bike-sharing systems has not been thoroughly examined. Radzimiński and Dzięcielski (2021) conducted a study in the city of Poznań that explored integration and substitution between public bicycles and public transport. The metropolitan bike-sharing system in Poland has also garnered interest, with studies highlighting the various needs of cities, towns, and villages in integrating bike-sharing as a means of transport for residents, tourists, and recreational cyclists (Kwiatkowski, 2021). Consequently, our study addresses this knowledge gap by investigating modal substitution induced by urban cycling in the Polish city of Lodz and seeks to establish the significance of financial factors in driving this change.

3. METHODOLOGY

3.1 Research sample

The operator of the bike-sharing system in Lodz during the survey period was Nextbike Polska, managing a fleet of 1,584 vehicles. In 2019, this system ranked fourth among the 15 largest bike-sharing systems in Poland (as shown in Table 1).

The Lodz public bicycle system followed a station-based operational model, comprising 157 stations. In 2019, the system recorded 1.4 million rentals, making it the third-largest in terms of usage in Poland.

Table 1. Number of bicycles and bike rentals in the 15 largest bike-sharing systems in Poland in 2019

City	Name of the bike-sharing system	Number of bikes	Number of rentals
Warsaw	Veturilo	5,500	5,316,910
Wroclaw	Wrocławski Rower Miejski	2,065	1,817,783
Poznan	Poznański Rower Miejski	1,700	1,134,360
Lodz	Łódzki Rower Publiczny	1,584	1,469,419
Krakow	Wavelo	1,500	839,445
Lublin	Lubelski Rower Miejski	961	658,700
Szczecin	Bike_S	700	410,000
Bialystok	BiKeR	659	539,396
Katowice	City by bike	632	261,836
Bydgoszcz	Bydgoski Rower Aglomeracyjny	590	245,000
Kalisz	Kaliski Rower Miejski	283	118,400
Radom	Radomski Rower Miejski	270	82,800
Czestochowa	Częstochowski Rower Miejski	185	149,200
Gliwice	Gliwicki Rower Miejski	150	84,800
Kolobrzeg	Kołobrzeski Rower Miejski	135	88,000

Source: Mobilne miasto (2020).

The changes in travel behaviour among Lodz residents, influenced by the availability of bike-sharing services and their financial determinants, were investigated through a survey conducted using the Computer Assisted Personal Interview (CAPI) technique. This survey took place from March to June 2019. The survey sample was non-random and purposive, consisting of individuals who had rented a bicycle from the municipal system in Lodz at least once. To ensure the sample met the target group specifications, a screening question was used at the beginning of the survey. Four interviewers were engaged and provided with thorough instructions to ensure accurate data collection. The survey was conducted among passers-by near bike stations. Control variables such as respondents' age, gender, education, and monthly household income were included in the study. Table 2 presents the characteristics of the sample based on these attributes.

Table 2. Characteristics of the research sample

	N	%
Age		
Up to 18 years old	13	4.39
19–26 years old	146	49.33
27–35 years old	68	22.97
36–45 years old	55	18.58
46 and more	14	4.73
Gender		
Woman	154	52.03
Man	142	47.97
Education		
Basic and primary	14	4.73
Secondary technical	42	14.19
General secondary education	70	23.65
Incomplete higher education	61	20.61
Higher	102	34.46
No data	7	2.36
Monthly household income		
Up to PLN 2,000	60	20.27
PLN 2,000–5,000	112	37.83
PLN 5,000–10,000	74	25.00
Over PLN 10,000	20	6.76
No data	30	10.14
Total	296	

Source: own work.

3.2. Measurement and data analysis method

Respondents indicated changes in their travel behaviour resulting from the availability of public bicycles in Lodz using 11 proposed alternatives:

– they abandoned traveling by private car in favour of public bicycles permanently, frequently, or occasionally,

– they abandoned traveling by public transport in favour of public bicycles permanently, frequently, or occasionally,

– they abandoned walking or pedestrian movements in favour of public bicycles permanently, frequently, or occasionally,

– they continued using their usual mode of transportation and considered public bicycles as an additional means of transport,

– they did not change their behaviour.

The financial incentive for using the bike-sharing service was assessed by inquiring whether cost savings motivated their use of the city bikes. The perceived affordability of the bike-sharing service was evaluated by asking respondents to rate their satisfaction with the price of renting a city bike using a 5-point Likert scale (1 = strongly unsatisfactory, 5 = strongly satisfactory).

Statistical analyses involved the Fisher test, the chi-square test of independence, and the Mann-Whitney test to examine the relationships between variables. The significance of the tests was assessed at 10%, 5%, and 1% significance levels. Effect sizes were determined using V-Cramer coefficients and correlation coefficients. All calculations were performed using Stata 17 software.

4. RESULTS

4.1. Modal substitution as a result of bike-sharing system availability

The influence of the public bike system's availability on altering respondents' travel behaviour is presented in Table 3. The respondents had the option to choose multiple answers (mutually exclusive options were eliminated by the authors). Among those who regularly use public mass transport, approximately 25% reported occasionally substituting public transport with bicycles. Slightly fewer respondents mentioned frequent substitution of public transport with bicycles. Significantly fewer respondents indicated a permanent shift compared to the „frequently" and „occasionally" categories. Similar patterns emerged among pedestrians, where a significantly smaller proportion permanently switched from walking to using a city bike compared to those who did it frequently or occasionally. These results highlight public bicycles as the primary alternative to both public transport and pedestrian mobility. However, the ongoing trend of replacing these modes of transportation with public bicycles may not be sustainable. In contrast, public bicycles are considerably less competitive with private cars, but when a change occurs, it tends to be frequent or occasional. Such changes also persist longer compared to pedestrians and public transport users.

Table 3. Modal substitution of respondents

Type of change in travel behaviour	Persistence of change	N	%
Abandoned traveling by private car in favour of public bicycles	Permanently	27	9.12
	Frequently	47	15.88
	Occasionally	38	12.84
Abandoned traveling by public transport in favour of public bicycles	Permanently	15	5.07
	Frequently	66	22.30
	Occasionally	73	24.66
Abandoned walking or pedestrian movements in favour of public bicycles	Permanently	12	4.05
	Frequently	51	17.23
	Occasionally	50	16.89
Perception of the influence of the availability of the bicycle system on the change in travel behaviour	I continue to use the same means of transport; a public bike serves as an additional option.	94	31.76
	The availability of the bicycle system has not led to a lasting alteration in transportation methods.	63	21.28

Source: own work.

One-third of respondents stated that public bikes served as an additional mode of transport, and they continued to use other existing mobility options with the same frequency. Approximately 20% of respondents believed that access to the bicycle system did not lead to a permanent change in their travel behaviour.

4.2. The impact of financial determinants on the travel behaviour change due to bike-sharing system availability

The relationship between respondents' declared changes in travel behaviour and financial predictors (including user income, the motive of saving transport expenses when renting a bicycle, and satisfaction with the price of renting a bicycle) was analysed. Income levels did not exhibit a statistically significant relationship with any variation of travel behaviour change. Out of 296 respondents, 84 (28.4%) indicated cost savings in transport expenses as a motivating factor for choosing a public bicycle, with half of them reporting an average monthly household income below PLN 5,000. Using the chi-square test of independence, the association between the financial motive for choosing a city bike and changes in travel behaviour in response to the availability of bike rental services in the city was assessed. The results of the analyses are presented in Table 4.

Table 4. Analysis of the frequency of answers for using a city bike, depending on whether respondents indicated "cost saving" as the most important reason for using a bike

Answer		Using a city bike because of cost savings				p	V
		No		Yes			
		N	%	N	%		
"I have permanently transitioned from using a car to a city bike."	No	195	91.98	74	88.10	0.295	0.061
	Yes	17	8.02	10	11.90		
"I frequently opt for a city bike over using a car."	No	177	83.49	72	85.71	0.637	0.027
	Yes	35	16.51	12	14.29		
"I occasionally choose a city bike over a car."	No	183	86.32	75	89.29	0.492	0.040
	Yes	29	13.68	9	10.71		
"I have permanently transitioned from using a public transport to a city bike."	No	203	95.75	78	92.86	0.306	0.060
	Yes	9	4.25	6	7.14		
"I frequently opt for a city bike over using a public transport."	No	171	80.66	59	70.24	0.052*	0.113
	Yes	41	19.34	25	29.76		
"I occasionally choose a city bike over a public transport."	No	164	77.36	59	70.24	0.200	0.075
	Yes	48	22.64	25	29.76		
"I have permanently transitioned from walking to a city bike."	No	204	96.23	80	95.24	0.698	0.023
	Yes	8	3.77	4	4.76		
"I frequently opt for a city bike over walking."	No	181	85.38	64	76.19	0.059*	0.110
	Yes	31	14.62	20	23.81		
"I occasionally choose a city bike over walking."	No	184	86.79	62	73.81	0.007***	0.156
	Yes	28	13.21	22	26.19		
"I continue to use the same means of transport, with the bicycle as an additional option."	No	140	66.04	62	73.81	0.195	0.075
	Yes	72	33.96	22	26.19		
"There has been no permanent change in my means of transportation."	No	161	75.94	72	85.71	0.064*	0.108
	Yes	51	24.06	12	14.29		

Explanations: p – empirical significance level of the chi-square test of independence (*p < 0.1, **p < 0.05, ***p < 0.01); V – V-Cramer coefficient (effect size).

Source: own work.

Cost savings for using city bicycles exhibited a highly statistically significant relationship (at the 1% significance level) with occasionally substituting walking with city bicycles, although the strength of this relationship was weak. At the 10% significance level, statistical significance was also observed among respondents who frequently substituted public transport with city bikes, occasionally

substituted walking with city bikes, or experienced no permanent change in their travel behaviour. In all cases, the strength of the relationship ranged from weak to very weak.

Respondents' satisfaction with the price of renting public bikes is summarized in Table 5. Satisfactory and very satisfactory ratings were prevalent, accounting for over 70% of respondents in total, indicating high financial accessibility of the service. This high satisfaction likely stems from the first 20 minutes of bicycle usage being free of charge and the dense network of stations, particularly in the city centre (on average 5.35 stations per 10 sq. km of the city area), making it possible to reach them within this time limit. Similar to other Polish and European cities, the price list rewards frequent and short-term bicycle users with no incurred costs and imposes fees that increase substantially with each subsequent hour of rental for longer routes (Fishman *et al.*, 2013; Kwiatkowski, 2018).

Table 5. Satisfaction ratings with the price of renting a shared bike

	1	**2**	**3**	**4**	**5**	**Difficult to say**	**Average**	**Median**
N	3	27	36	110	109	11	4.04	4
%	1.01	9.1	12.2	37.2	36.8	3.7	-	-

Source: own work.

Subsequently, using the Mann-Whitney test, respondents' average satisfaction ratings with the price of renting bicycles were compared based on their declared changes in travel behaviour. The results are presented in Table 6.

Table 6. Results of comparing user satisfaction with the price of using the city bike system depending on the declared change in travel behaviour related to the introduction of the city bike

Answer		**Price**		**Z**	**p**	**|r|**
		M	**SD**			
"I have permanently transitioned from using a car to a city bike."	No	3.83	1.26	-2.483	0.013**	0.144
	Yes	4.41	0.85			
"I frequently opt for a city bike over using a car."	No	3.84	1.23	-1.864	0.062*	0.108
	Yes	4.11	1.26			
"I occasionally choose a city bike over a car."	No	3.92	1.21	0.990	0.032**	0.058
	Yes	3.66	1.44			
"I have permanently transitioned from using a public transport to a city bike."	No	3.87	1.25	-0.528	0.597	0.031
	Yes	4.13	0.92			
"I frequently opt for a city bike over using a public transport."	No	3.83	1.24	-1.892	0.059*	0.110
	Yes	4.09	1.21			

Answer		Price		Z	p	|r|
		M	SD			
"I occasionally choose a city bike over a public transport."	No	3.96	1.18	1.524	0.127	0.089
	Yes	3.67	1.38			
"I have permanently transitioned from walking to a city bike."	No	3.91	1.20	0.804	0.422	0.047
	Yes	3.33	1.87			
"I frequently opt for a city bike over walking."	No	3.84	1.25	-1.395	0.163	0.081
	Yes	4.08	1.18			
"I occasionally choose a city bike over walking."	No	3.84	1.24	-1.647	0.099*	0.096
	Yes	4.10	1.99			
"I continue to use the same means of transport, with the bicycle as an additional option. "	No	3.89	1.28	0.693	0.488	0.040
	Yes	3.87	1.16			
"There has been no permanent change in my means of transportation."	No	3.91	1.26	1.276	0.202	0.074
	Yes	3.79	1.14			

Explanations: M – average; SD – standard deviation; Z – standardized Z-score for Mann-Whitney test statistics; p – empirical significance level of the Mann-Whitney test (*p < 0.1, **p < 0.05, ***p < 0.01); |r| – correlation coefficient (effect size).

Source: own work.

Statistically significant differences in the assessment of satisfaction with the price of using a city bike were revealed among people who switched to a city bike from a car permanently (at the 5% significance level), frequently (at the 10% significance level), or occasionally (at the 5% significance level). Among residents who frequently give up travelling by public transport in favour of a city bike, and among people who occasionally give up walking in favour of a city bike this relationship was significant at the 10% significance level. The switch from using a car to a city bike permanently yielded the most substantial effect size. However, in all cases, the magnitude of the observed effects was low.

Statistically significant differences in satisfaction ratings for using a city bike were observed among individuals who permanently switched from using a car to a city bike (at the 5% significance level), those who frequently made this change (at the 10% significance level), or those who occasionally did (at the 5% significance level). Among residents who frequently substituted public transport with city bikes and those who occasionally replaced walking with city bikes, this relationship was significant at the 10% significance level. The most substantial effect size was observed for the permanent switch from using a car to a city bike. However, in all cases, the observed effects were of low magnitude.

5. DISCUSSION

Our analysis reveals that bike-sharing serves as an additional mobility option for respondents without significantly altering their travel behaviour. Despite the increasing number of users in the Lodz bike-sharing system until 2019 and the noticeable share of trips made using rented bikes in the modal split (Borowska-Stefańska *et al.*, 2020), car travel remains the dominant mode of urban transportation in the city (Wiśniewski *et al.*, 2023). Other analyses also emphasize the significant role of private cars and the limited use of bicycles in the mobility of residents of Polish cities (Bartosiewicz and Pielesiak, 2019). Furthermore, studies on bike-sharing system performance in Poland indicate relatively low utilization, with the average TDB (the number of trips per day per bike) in 2018 being 1.93, lower than observed in larger global cities or Chinese cities, ranging from 0.12 to 4.89 (Bieliński *et al.*, 2019).

Nevertheless, our findings do indicate some impact of the bike-sharing system, which varies depending on the previous modes of travel. The most substantial behavioural change observed was the shift from public transport to public bicycles. To a lesser extent, public bicycles became competitive with walking, and to the smallest extent, they replaced individual car travel. These findings are consistent with results from studies conducted in various countries, confirming the competitiveness of public bicycles with public transport (Jäppinen *et al.*, 2013; López-Casasnovas, 2009; Jin, 2019; Wolny-Kucińska, 2020). Similar observations apply to e-bikes (Bielinski *et al.*, 2021). In Lodz, the well-developed public transport network, especially in the city centre, is countered by high traffic congestion, resulting in extended travel times, delays, and a decrease in the attractiveness of this mode of transportation (Borowska-Stefańska *et al.*, 2023; Wiśniewski *et al.*, 2023). Consequently, public transport users in Lodz may seek alternative means of transportation.

Considering the positive impact of cycling on health, changes from public transport to cycling should be viewed favourably. Conversely, switching from walking to cycling should be regarded as neutral. It's important to acknowledge the hierarchy of green transport, where walking trips are the most environmentally beneficial, healthy, and cost-effective (provided suitable pedestrian infrastructure exists). In contrast, cycling systems require financial investments for setup and operation, and they generate CO2 emissions throughout their life cycle due to system maintenance, vehicle relocation, and operation (Chen *et al.*, 2023). Thus, cycling may not be an attractive option for travellers on short pedestrian journeys, which is a common scenario in Lodz (Borowska-Stefańska *et al.*, 2020).

The most desirable shift, from private car travel to cycling, is optimal for balancing transport systems, reducing greenhouse gas emissions (Cao and Shen, 2019; Chen *et al.*, 2022b), and promoting public health. However, this transition is inadequately achieved in the studied city, consistent with findings from other studies (e.g., Midgley, 2011; Johansson *et al.*, 2019; Fishamnn *et al.*, 2014) re-

garding low car-to-bicycle mode substitution. This is attributed to individuals' heavy reliance on cars. Barbour *et al.* (2019) drew more extensive conclusions about the behaviour of registered users of bike-sharing systems, suggesting that people's dependence on cars leads them to rent bicycles less frequently and substitute bicycle travel with car travel when access to a bicycle system is unavailable. Furthermore, studies on the impact of bicycle systems on reducing car ownership suggest a small but immediate effect (Basu and Ferreira, 2021).

In the case of Lodz, despite the presence of a bike-sharing system with an efficiently distributed station network and a substantial number of bikes (Borowska-Stefańska *et al.*, 2020), it does not constitute an attractive alternative to car travel, especially considering the prevalent traffic congestion. The high dependence of Polish society on cars, the nature of car travel primarily for commuting to workplaces, and significant travel distances due to urban sprawl in urban regions motivate car usage (Bartosiewicz and Pielesiak, 2019). In 2019, the Lodz bike-sharing system also had a concentration of bike stations in the city centre, affecting its accessibility in the outskirts. Basu and Ferreira (2021) estimated a 3.3% reduction in kilometres travelled by car with the introduction of a new cycling station, which increased to 10% when integrated with public transport and when bike stations were located within one kilometre of each other.

Our results reveal a relationship between financial factors related to bike-sharing (cost-saving motives and satisfaction with rental prices) and certain changes in travel behaviour. Respondents who occasionally and frequently substituted walking or public transport with cycling were more likely to emphasize the importance of cost savings. In both cases, this behaviour change can be attributed to the cost-free nature of cycling for the first 20 minutes. Additionally, our research suggests that low bike rental costs have the potential to reduce car travel. Among respondents highly satisfied with the rental price, there was a higher incidence of permanently, frequently, or occasionally giving up car travel. However, these relationships are of weak magnitude. These findings align with other research indicating the significance of bike travel costs in influencing car-to-bike mode substitution (Narayanan *et al.*, 2023). In other studies, the importance of bicycle rental costs for intending to use the service was more pronounced among students compared to office workers (Duan *et al.*, 2023).

It's important to recognize that this study has certain limitations, primarily related to the non-representative nature of the research sample. Since the sample is not representative, we cannot extrapolate the research findings to encompass the entire population of Lodz's citizens or all users of Lodz's bike system. Such an attempt could potentially lead to biased conclusions, particularly when considering specific groups of residents who are not adequately represented in the research sample. Furthermore, the sample size is limited, which posed a challenge when attempting to introduce more advanced statistical techniques, such as multivariate regression analysis. Therefore, future developments of this study should prioritize

achieving sample representativeness in terms of the general sociodemographic structure and spatial distribution of respondents, as well as expanding the sample size for more robust analysis.

6. CONCLUSIONS

Our study primarily focused on examining modal substitution options involving shared bikes. These analyses contribute significantly to addressing a knowledge gap concerning the adoption of shared bicycles in Polish cities. The research conducted among shared bicycle users in Lodz revealed that the most substantial impact observed was the substitution of public transport trips with bicycle trips, while the influence on replacing car trips was minimal. Such patterns and the limited degree of modal substitution do not align with expectations and do not support the goals of transitioning to sustainable urban mobility. The bike-sharing system does not appear to be an effective tool for facilitating this transition by substituting private and multimodal trips with shared bikes and public transport.

In our study, we examined the significance of financial factors in the shift from other modes of transportation to bike rentals. What sets our approach apart from other approaches is the consideration of two predictors of this substitution: the financial incentive for using the bike-sharing service and the perceived affordability of the bike-sharing service. We have indeed identified a statistically significant relationship between satisfaction with pricing and the decision to give up car travel in favour of cycling, as well as the cost-saving motive and the substitution of walking and public transport travel with biking. However, these relationships are relatively weak, underscoring the importance of other contributing factors.

These findings have implications for policymakers. To enhance the impact of cycling in reducing car journeys, it is imperative to promote cycling systems and introduce more flexible and financially attractive conditions for bike rentals from the user's perspective. The promotion of cycling systems should emphasize the financial benefits associated with replacing car trips with bike-sharing. Additionally, encouraging multimodal journeys that combine first/last mile bike-sharing with public transport is essential. An illustrative example of innovative bike rental schemes is the one planned for implementation in Krakow, Poland, in 2023, offering the option to rent a city bike exclusively for one month.

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Tadeusz MARSZAŁ *

GERMAN MINORITY IN URBAN SPACE OF A TEXTILE MANUFACTURING CENTRE: THE CASE OF 19TH CENTURY CITY OF ŁÓDŹ

Abstract. German settlement in Poland has been the subject of numerous studies. The causes and determinants of migratory movements have been discussed extensively, while little attention has been paid to the spatial aspects of the phenomenon. The aim of this study, which is part of geographical and historical research, is to determine the size of the influx of migrants of German nationality into the rapidly developing textile production centre of Łódź in the 19th century, as well as the geographical origins and distribution of this nationality group in the urban space. These considerations are complemented by the identification of key issues related to the social integration and assimilation processes of the German minority. In the first half of the 19th century, the influx of skilled labour, almost entirely recruited from the German population, conditioned the development of the textile industry in Łódź. It also had a key influence on the demographic development of Łódź, which soon became the largest centre of textile production in Poland. In subsequent decades, there was a tendency among German immigrants towards separation in the sphere of professional and social activities, but already by the end of the 19th century the German community settled in Łódź was diverse in terms of the sense of nationality. In addition to a certain proportion of the immigrants who were already Polonised, there were persons declaring German nationality, as well as those undecided about the issue.

Key words: German settlement, national minority, Łódź, migration.

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1. INTRODUCTION

Germans have been settling Polish lands for centuries. German settlement, spontaneous until the middle of the 18th century, grew significantly towards the end of the century. Colonisation, mainly limited to rural settlements, over time increasingly involved an influx of German people into towns and newly established craft settlements. The beginnings of German settlement in today's Łódź urban agglomeration date back to the last decades of the 19th century. A particularly intense influx of this ethnic group was brought by the period of 19th century industrialisation. However, until the early 1820s, immigrants generally avoided the typically agricultural and neglected Łódź[1], which was surrounded by a ring of German peasant settlements established in the late 18th and early 19th centuries.

The creation of the Kingdom of Poland in 1815 allowed the initiation of measures to promote the economic development of the country. Łódź was among the settlement units indicated by the Polish government as particularly predisposed to industrial development – a small settlement with several hundred inhabitants, a *de facto* rural stead, though formally possessing a charter.

As a result of the measures taken by the government, Łódź experienced rapid economic development, with the number of inhabitants increasing more than sixfold in the third decade of the 19th century alone, reaching 4,700 by 1831. This demographic development was primarily the result of an influx of German settlers, whose share of the city's population reached 75% by the 1830s. The decrease in this ratio in the following decades did not mean a decrease in the number of German inhabitants in Łódź – it was only the result of the spontaneous and rapid development of this industrial centre, which was associated with a rapid influx of Polish and Jewish people into the city. Łódź, which still had a population of just over 30,000 in the mid-19th century, grew to around 300,000 inhabitants by the end of the century, and the city – still the largest concentration of German origin population in Central Poland – was inhabited by three nationality groups of a roughly similar sizes: Polish, Jewish, and German.

The issue of German settlement in Poland has been the subject of numerous studies by both Polish and German historians. The causes and determinants of migratory movements have been discussed extensively, while little attention has been paid to the spatial aspects of this phenomenon, especially in the Łódź region. The aim of this study, which is part of geographical and historical research, is to determine the size of the influx of migrants of German nationality into the rapidly developing textile production centre of Łódź in the 19th century, as well as the

[1] A report drawn up in 1820 by the mayor of Łódź on the religious composition of the inhabitants mentions 12 Evangelicals, probably of German nationality. Despite that, O. Kossmann did not mention any Evangelicals in 1820 and stated that Łódź had 767 inhabitants at that time, including 271 Jews. See Kossmann, 1966, p. 150.

geographical origins and distribution of this nationality group in the urban space. The discussion of the spatial aspects of German settlement in Łódź is complemented by the identification of key issues related to the processes of social integration and assimilation of the German national minority.[2]

2. THE BEGINNINGS OF GERMAN SETTLEMENT IN OLD ŁÓDŹ – THE PRE-INDUSTRIAL PERIOD

German rural settlement reached the area of Łódź in the 1780s. During the last two decades of this century, a number of new settlements populated by German immigrants were established in the royal and private estates in the area of the present-day urban agglomeration of Łódź.[3]

In 1793, as a result of the Second Partition of Poland, the Łódź region found itself within the borders of the Prussian state, whose authorities pursued a policy of settling German population in the newly occupied areas. Prussian colonisation *de facto* continued the earlier settlement processes of the pre-partition period.[4] The Prussian colonisation campaign was most intense between 1801 and 1806. Newcomers settled in existing villages or in new locations built from scratch. The area in which the colonisation campaign was undertaken in the early years of the 19th century was the secularised Łaznów estate (as well as the Wiączyń and Gałkówek estates).[5] In the autumn of 1800, 39 Swabian families were brought from southern Germany to Łaznów, for whom fifty plots of land of about 15–16 ha each were prepared in Łaznowska Wola (Grömbach).[6] New German agricultural colonies were established on government dominion land.[7] The largest and wealthiest

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[2] The issue of the origin and structure of the German minority in the Łódź region is discussed in detail also in: T. Marszał (2020), and T. Marszał (2022, pp. 25–51).

[3] Among them were Ruda Bugaj (1782), Mała and Wielka Brużyca (1782), Pustkowa Góra (1783), Rochów and Rochówek (1783), Ksawerów and Ksawerówek (1783), Słowik (1785), Dąbrówka (1788), Swędów (1789 or 1792), Lipiny (1790), Mała Nowa Wieś (1790), Janów–Mileszki (ca. 1790), Dąbrówka or Dąbrowa, (ca. 1790), Swędów (1792) and Holendry Radogoskie-Żabieniec (1793). In 1788, newcomers from Württemberg (Lutherans) and Alsace-Lorraine (Calvinists) settled in Gałkówek near Brzeziny.

[4] The essence and nature of these processes are presented in the article: J. Wąsicki, 1953, pp. 137–179.

[5] Under the Prussian partition, Łaznów was the seat of the Prussian administration of the Łódź district.

[6] The German name of the village was given at the request of the settlers, most of whom came from a village in Württemberg of the same name. Similarly, many other settled villages were named after the settlers' places of origin. For more on Łaznowska Wola see Woźniak, 2015, pp. 106–108.

[7] I.a. Bukowiec (Königsbach), Starowa Góra (Effingshausen), Olechów, Wola Rakowska (Koenigsbuch), and Markówka (Hochweiler, Hochwald).

Swabian village on Polish soil was Nowosolna (Neu-sulzfeld), to which the first sixty families arrived from Württemberg, Baden, Alsace, and the Palatinate in 1801 (Woźniak, 2015, p. 110).[8] As Germans came, owners of private estates near Łódź (including Stoki, Mileszki, Bedoń, and Chojny), ceded land to them (often lying fallow) in their estates for a small rent (see Rynkowska, 1960, p. 36).

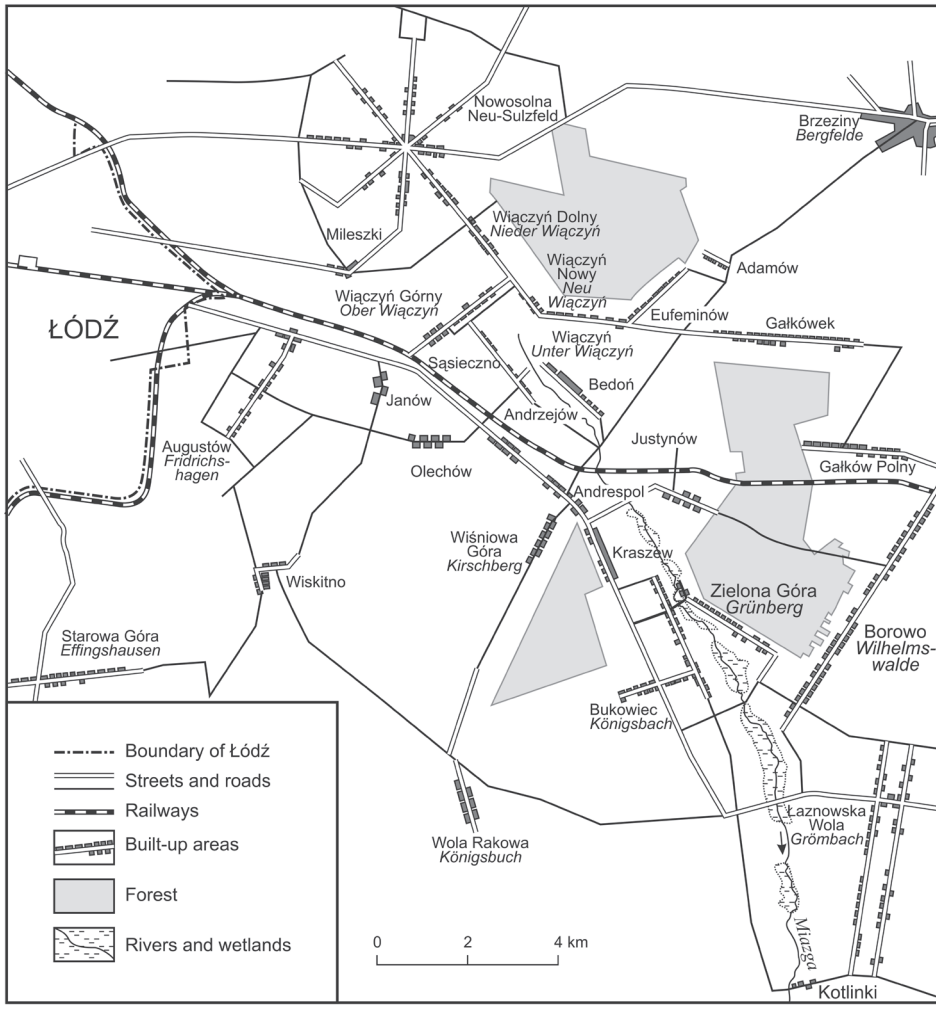

Fig. 1. German settlement until 1815 in the areas east of Łódź

Source: own work based, among others, on Schmit, 1942.

[8] Some of these families who did not have the cash to settle returned to Württemberg, while others went to Russia (Heike, 1979, p. 110).

According to the recommendations of Prussian authorities, newly founded villages were to be settled exclusively by German settlers – Nowosolna and Olechów were purely German. But since German colonisation also extended to villages already in existence in many settlements, some of the inhabitants were also of Polish nationality.[9]

The number of settlers arriving from Bavaria, Württemberg, and the Palatinate (see Kossmann, 1985, p. 147), and in the following years also from Poznań and Prussia[10], grew particularly rapidly in Nowosolna, which in the last years of the Prussian rule surpassed Łódź in terms of population.[11]

During the Prussian period, German-speaking newcomers also settled many other towns in the region and thus, even before 1815, the sparsely populated forested area around the small town of Łódź was becoming a region of increasingly intensive agricultural production. A particularly strong concentration of German settlement was in the area to the east of Łódź (see Fig. 1). In the following decades of the 19th century, a number of settlements settled by German colonists were incorporated into the borders of the rapidly developing industrial Łódź. The names of many inner-city settlement units and locations in the suburban zone of contemporary Łódź are related to the names of former settlements.

The turn of the 18th century was a period of an influx of German colonists mainly in rural areas. But it was also a time marked by some, initially small, movements of craftsmen of German nationality into the cloth production that was developing in many centres.[12]

3. INFLUX OF GERMAN POPULATION TO THE TEXTILE INDUSTRY OF ŁÓDŹ IN THE PRE-PARTITION PERIOD

After the Congress of Vienna, Łódź found itself within the borders of the Kingdom of Poland, established in 1815 and until First World War linked to the Russian Empire. In its first period of existence, until the outbreak of the 1830 uprising, its large autonomy allowed it to pursue its own economic policy aimed at the industrialisation of Poland. The government identified a number of centres designated for industrial development, while guaranteeing them support in the form of a number of privileges. The choice of Łódź and the surrounding area for

[9] E.g. Stoki and Sikawa, Wiśniowa Góra (Kirschberg), Karkoszka, Augustów, and Antoniew.

[10] Among them were many Moravian Brethren. See Eichler, 1921, pp. 62–63.

[11] Nowosolna, which did not have a city charter, was larger than Łódź until 1823. See Baranowski and Fijałek (eds), 1980, p. 143.

[12] In the pre-partition period, the largest centre of cloth production was Brzeziny (there were many clothiers of German origin).

the development of textile production was determined primarily by its favourable natural conditions: sufficient supply of water allowing the placement of the fulling and dyeing plants, numerous small rivers with rapid currents as a source of energy, and forests providing material for the construction of houses.

The turning point in the development of Łódź came in the 1820s when, as a result of a well-planned action by the government of the Kingdom of Poland, a textile production centre was established here.[13] Securing a workforce with the right skills and capital was a key condition for ensuring development. To this end, an extensive campaign was launched to bring in settlers mainly from Germany, but also from Bohemia and former Polish territories (Silesia and the Grand Duchy of Posen, where a large proportion of the population was of German nationality). Clothiers, weavers, and spinners were eager to migrate, motivated partly by the situation in their countries of residence, where textile manufacturing was in crisis due to competition from English mechanised mills. In the Kingdom of Poland the government protected domestic production through a system of protective tariffs.

Among other things, the settling clothiers were offered free land for construction and free building materials (cf. Janowicz, 1907, p. 18). In government towns set up as factory settlements, under the 1820 decree of the royal governor, the immigrants settling there were provided with, among others, the opportunity to live in low-rent houses built by the government[14], free timber to build houses, and assistance in building an evangelical church and housing for the pastor (Gąsiorowska, 1965, p. 74). The children of the settlers were able to study in schools in their native language. The government also provided loans for the purchase of workshops and raw materials for production. Settlers were exempted from paying taxes for the first few years, and their sons were not required to perform military service. A further decree was issued in 1823, which not only confirmed but also extended the previously granted benefits. In 1824, assurances were given to factory owners that in the next decade the ban on imports of cloth products would not be revoked or amended, and the right to import materials needed for production from abroad would be maintained (Koszutski, 1905, p. 44). The government attached particular importance to the construction of water facilities, fulling mills and bleacheries, supporting these investments organisationally and financially. To receive support, one had to be suitably qualified and to fulfil certain previously accepted obligations, under the threat of losing rights to the allotted parcel of land and eviction.

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[13] The history of the development of industrial Łódź is the subject of a number of publications, among which special attention should be paid to: A. Ginsbert, 1962; M. Koter, 1969; W. Puś, 1987; and M. Koter, S. Liszewski, T. Marszał and S. Pączka, 1993, pp. 9–34.

[14] After 1822 in Łódź, a house could be bought on favourable terms by repaying the amount due in convenient instalments spread over 10 years (Rynkowska, 1951, pp. 181–187).

The situation of industrial settlers in the Kingdom of Poland was secured from the legal point of view by agreements concluded with state authorities (and municipal after 1827) in the case of government towns, or with owners in the case of private estates.

The influx of industrial settlers to the previously omitted Łódź was initiated by the preparation in 1822 of 202 plots of land in the newly established clothmaking settlement of Nowe Miasto (Flatt, 1853, pp. 61–62).

The first foreigner to initiate the development of industrial Łódź was Karol Sänger, who came from Chodzież. Thanks to him, in the autumn of 1823, the first group of immigrants arrived in Łódź – a dozen or so master clothiers and a shearer from Saxony, as well as several experts in the construction of weaving workshops and houses. Between 1823 and 1825, nearly 200 skilled craftsmen settled in the town, most of whom (around 60%) were weavers. The establishment of a settlement for cotton and linen weavers with 307 plots in 1824 and a settlement for linen spinners with 167 plots in 1825 in the following years resulted in a further fast-growing migration of skilled German settlers. The first cotton weavers arrived in September 1824.[15]

Many of the industrial settlers came from Saxony, a region with liberal migration policy, where the textile industry, which had developed strongly in the 17th and 18th centuries, was experiencing difficulties after the loss of eastern markets. Impoverished Saxon weavers migrated en masse to the Kingdom of Poland from the mid-1820s until the outbreak of the November Uprising. The influx of Saxon settlers was particularly intense between 1824 and 1830, and between 1837 and 1844 (Missalowa, 1964, pp. 76, 83). Most of them, including many cotton weavers, headed for Łódź and the surrounding textile production centres.

Migrants arriving in Łódź, which was becoming a fast-growing industrial centre, mostly came from: (cf. Rynkowska, 1951, pp. 31–35; Bajer, 1958, p. 53)

– Prussia (Brandenburg) and Lower Silesia,
– Saxony, especially its eastern part,
– Bohemia,
– Grand Duchy of Posen.

The first settlers to arrive in Łódź were mainly Saxons and Germans from Bohemia (North Bohemia). In the following years, the number of refugees from Silesia grew (Staszewski, 1931, p. 264).

In the first Łódź settlement, "Łódka", settled between 1825 and 1830, about half of the settlers came from Saxony, about a third were immigrants from Bohemia, and the rest were almost exclusively from Prussian Silesia (Rynkowska, 1951, p. 34).

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[15] Among others from Weissbach (now Bily Potok) near Frýdlad and Georgswalden (now Jiřikov) in North Bohemia (Friedman, 1933, pp. 123–124).

One of the first activities of the immigrants coming to the city was associating in craft guilds. In 1824, the linen makers guild and the clothiers guild were established in Łódź (Rynkowska, 1951, pp. 210–211). In 1825, the Master Craftsmen House ("Meisterhaus") was opened and became the centre of social and cultural life for German craftsmen. In the same year, a brotherhood of apprentice weavers became active. In later years guilds were organised in Łódź grouping representatives of other professions (Sztobryn, 1999, p. 15).

A special government commissioner was sent to Saxony, Bohemia, and Prussia to recruit industrialists with more substantial capital. These activities bore fruit and in the second half of the 1920s, Łódź welcomed, among others: Frederick Wendisch from Chemnitz (Saxony), Daniel Ill from Groschönau (Saxony), Jan Traugott Lange from Chemnitz (Saxony), Ludwig Geyer from Neugersdorf near Lobau (Saxony), and Tytus Kopisch from Schmiedeberg (Lower Silesia). Some of them, after settling in the Kingdom, took over government production facilities.[16] The arrival of wealthier factory owners meant that the previous equality of economic positions among the settlers was disturbed, and that small-scale manufacturers, often working domestically, became a link in a production chain dependent on wealthier entrepreneurs.

The spatial development of the textile production centre of Łódź was complemented by the establishment of the Ślązaki weaving and spinning settlement with 42 plots in 1828. All these government actions resulted in a total of 366 plots of land being taken over by immigrants arriving in Łódź by 1829 (see Staszewski, 1931, p. 272). As early as 1826, the first German school, subordinate to the municipal authorities, for the children of the settlers – an Evangelical primary school – was set up in Łódź.

In the 1820s (up to the outbreak of the November Uprising), around a thousand immigrant craftsmen of German origin, together with their families, settled in Łódź – which still had a mere 799 inhabitants in 1821 – which means an estimated arrival of around 4,000 people of this nationality.[17] The influx of migrants, among whom cotton and linen weavers predominated, was particularly intense between 1826 and 1829 (cf. Fig. 2).

As a result of the demographic processes taking place in the third decade, the nationality structure of Łódź changed completely, and by the turn of the 1820s it had become a city with a large proportion of immigrant German-speaking population and one of the main German population centres in Central Poland.[18] The

[16] For more on industrialists of German nationality who came to Łódź in the 19th century, see Lück, 1934, pp. 342–344, and Pytlas, 2006, pp. 148–156.

[17] According to A. Rynkowska, between 1823 and 1830 approximately 3,500 immigrants arrived in Łódź. See Rynkowska, 1951, p. 31.

[18] A. Ginsbert reported that 1,029 immigrant families settled in Łódź between 1822 and 1831 (see Ginsbert, 1962, p. 17). According to J. Janczak, in 1830 there were 3,200 Germans living permanently in Łódź, which accounted for three-quarters of the city's total population (4,300 people) (see Janczak, 1982).

immigrant nature of Łódź's demographic development is confirmed by data stating that in 1839 as many as 68% of its permanent inhabitants were allochthones (born outside the city).[19]

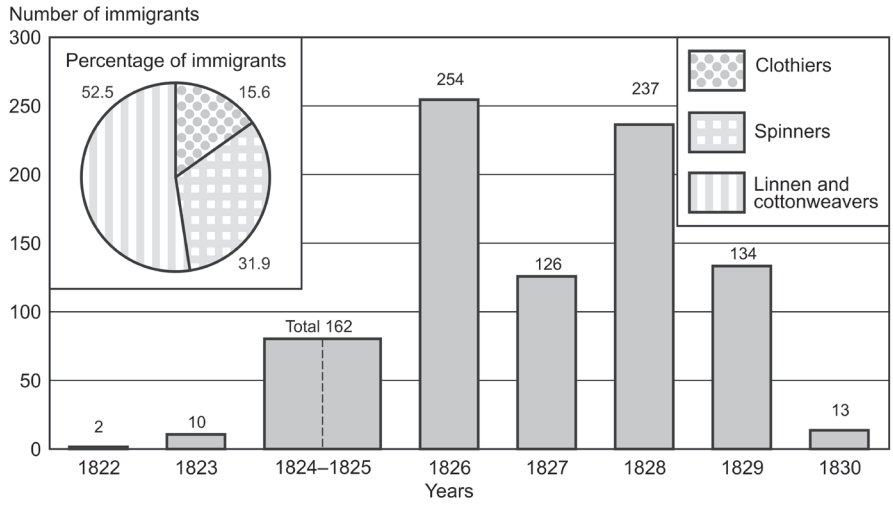

Fig. 2. Number and occupational structure of migrants settled in Łódź from 1822 to 1830
Source: own work based on A. Rynkowska, 1951.

In the pre-uprising decade, industrial settlers dominated among the newcomers from Germany. The influx of skilled labour, almost entirely recruited from the German population, conditioned the development of the cloth industry, both in Łódź and in other textile manufacturing centres in the Kingdom of Poland. The period of the first increased influx of German craftsmen into Polish industry, the greatest intensity of which occurred in the middle of the third decade of the 19th century, ended with the outbreak of the November Uprising.

4. INTER-UPRISING PERIOD (1831–1862)

The November Uprising and the difficult political situation after its collapse – reflected in the restriction of the Kingdom of Poland's independence in the sphere of economic policy – were of great significance from the point of view of German settlement. Opportunities for productive investment declined and the effects of the first major economic crisis, which lasted for several years, were felt particularly

[19] Kossmann, 1936, p. 36 [after:] Baranowski and Fijałek (eds), 1980, p. 204.

strongly by German craftsmen involved in textile production. The uprising resulted in the economic crisis of 1830–1834, which put much of the immigrant German population out of work. For many clothiers in the Łódź region, the outbreak of the uprising spelled economic disaster. The effects of the ongoing hostilities were compounded by retaliatory changes in Russia's economic policy – a reduction in Polish-Russian trade relations, cutting off sources of raw materials and markets. These steps were particularly acute in a situation of very few orders placed by the Polish government for the military.

But already the years 1837−1845 brought a second wave of migration of craftsmen from Saxony, who headed primarily for Łódź and the surrounding manufacturing centres. As in the second half of the 1820s, the largest number of migrants came from eastern Saxony (the area around Chemnitz and Dresden), where a strong textile manufacturing area developed near the border with Bohemia (cf. Missalowa, 1964, p. 78). The Saxon migrants almost exclusively consisted of skilled weavers and professionals familiar with textile machinery, and only a very small group of unskilled labourers. After 1845, the influx of new migrants from Saxony almost completely stopped. Between 1837 and 1845 there was also an influx of craftsmen from Bohemia and Moravia, mainly from the northern Sudetenland adjacent to the Saxon border. It was a region with a predominantly German population, so the majority of newcomers were from this nationality group. The incoming settlers from Bohemia, unlike those from Saxony, were not always highly qualified professionally and, in terms of occupation, it was a much more diverse migration, with a high proportion of labourers and poor people.

In 1861, among the 383 journeymen temporarily living in Łódź (on temporary passports) and employed in textile production, about half came from the Prussian partition, nearly a third from Saxony, almost a fifth from Bohemia and Moravia, while only a couple of people came from other German-speaking regions.[20]

The crisis following the collapse of the November Uprising, caused by Russia's restrictive policy and the introduction of customs duties on cloth exports to that country, proved short-lived and in the long term had little impact on Łódź's booming industrial production. As early as in the second half of the 1830s and early 1840s, as a result of a strong influx of German industrial settlers, the number of Łódź inhabitants increased significantly. Between 1833 and 1845, Łódź recorded a more than threefold increase in population (from 5,700 to nearly 17,300) (Janowicz, 1907, p. 29) and became the second largest city in the Kingdom of Poland, after Warsaw (Janczak, 1982, p. 50).

[20] *Lista imienna czeladzi różnej profesii, cudzoziemców, przebywających za paszportami w m. Łodzi* (1961), WAPŁ, 148/2406, k. 34-45 [after:] Missalowa (ed.), 1957, pp. 82–93; and Missalowa, 1964, pp. 83–84.

According to O. Kossmann's estimates, probably slightly overestimating the number of people of German nationality in Łódź[21], this ethnic group in the first half of the 1830s accounted for nearly three-quarters of the city's population, and by the end of that decade its share further increased slightly (see Table 1). However, the population of German nationality given by the magistrate of Łódź in October 1851 was undoubtedly underestimated at 5,800 (1,440 families), which accounted for 32% of the city's permanent residents (Rynkowska, 1960, table after p. 86). According to E. Rosset, in 1857 Łódź had a population of 26,100, of which 41.1% (10,700) were German, while in 1860 it had 32,600 inhabitants, of which 37.3% (12,200) were ethnic Germans (Rosset, 1928, p. 336). These figures for the German minority, due to underreporting, are highly debatable.[22]

Table 1. Nationality structure of permanent residents of Łódź in 1831–1839

Nationality	Year					
	1831		1836		1839	
	thousand	%	thousand	%	thousand	%
Polish	0.8	17.4	0.8	13.9	1.1	13.2
German	3.5	74.1	4.4	74.8	6.7	77.7
Jewish	0.4	8.5	0.7	11.3	0.8	9.1
Total	4.7	100.0	5.9	100.0	8.6	100.0

Source: Kossmann, 1936, pp. 28–29, 47; and Kossmann, 1966, p. 164.

In the 1830s, the number of inhabitants of German nationality in Łódź almost doubled. Its largest concentration throughout the fourth decade of the 19th century was the weaving settlement located along the town's main street, which in 1839 was home to just under 2,200 settlers, almost exclusively of German nationality. Similarly high, exceeding 90%, was the proportion of representatives of this ethnic group in the remaining districts of Łódź, except for the "Old Town" (cf. Fig. 3 and Fig. 4). In the "New Town", already in 1832 with a population of more than

[21] This overestimation is due to the estimation methodology adopted. The nationality composition for 1831 was determined by O. Kossmann by indirect means guided, among other things, by the sound of the surnames and using a list of the financial burdens of the Catholic population, which led to a reduction in the Polish nationality population. In the case of the population estimates for 1836 and 1839, he considered the religious structure and nationality, which also to some (small) extent overestimated the German settlers by including the population of Polish nationality migrating from the Prussian partition.

[22] The weaknesses of the statistics relating to the nationality structure of the inhabitants of Łódź before First World War are presented in detail in chapter IV of the work by J. Janczak, 1982, pp. 107–135.

1,000 inhabitants, 9 out of 10 people were of German nationality. The nationality structure in the oldest part of Łódź, or the "Old Town", was quite different, where Poles remained the most numerous ethnic group in the 1830s. However, their percentage gradually decreased, mainly in favour of the Jewish population and those of German origin (cf. Fig. 3 and Fig. 4). In this northernmost part of the city, the percentage of the German minority did not exceed a quarter in the late 1830s.

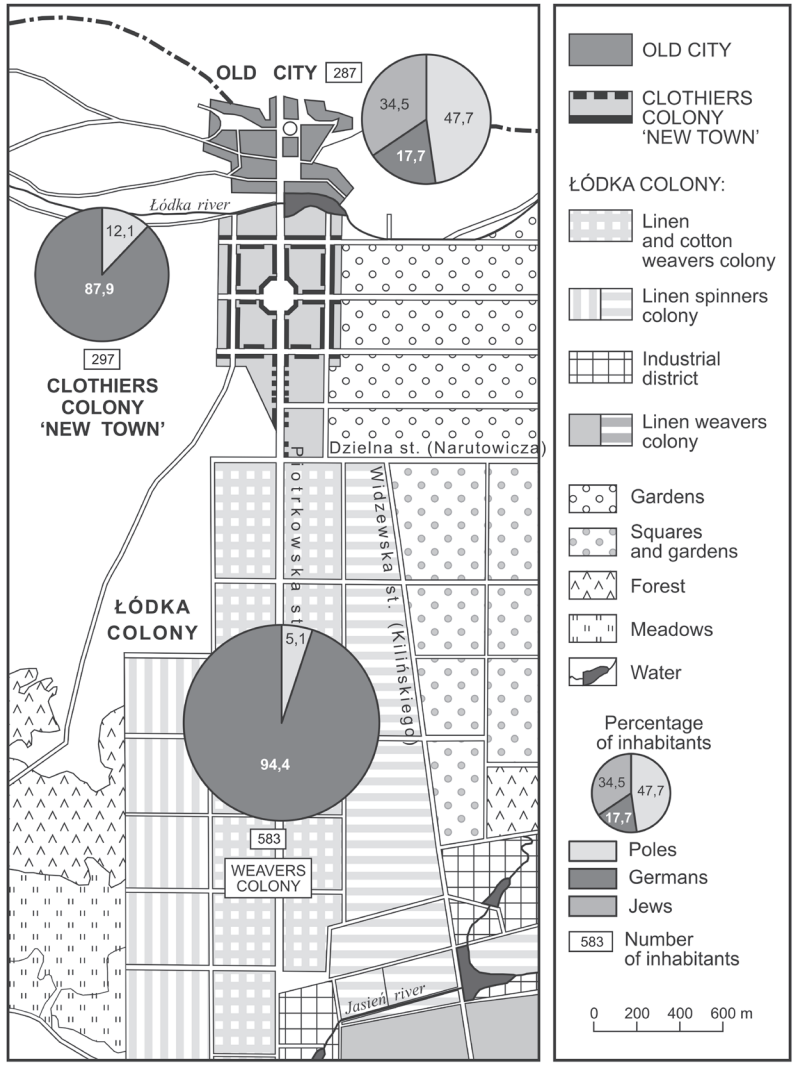

Fig. 3. Nationality structure of the population of Łódź (by number of families) in 1831 by districts

Source: own work based on: Kossmann, 1936, p. 28; Kossmann, 1966, p. 151; and Kossmann, 1985, p. 39.

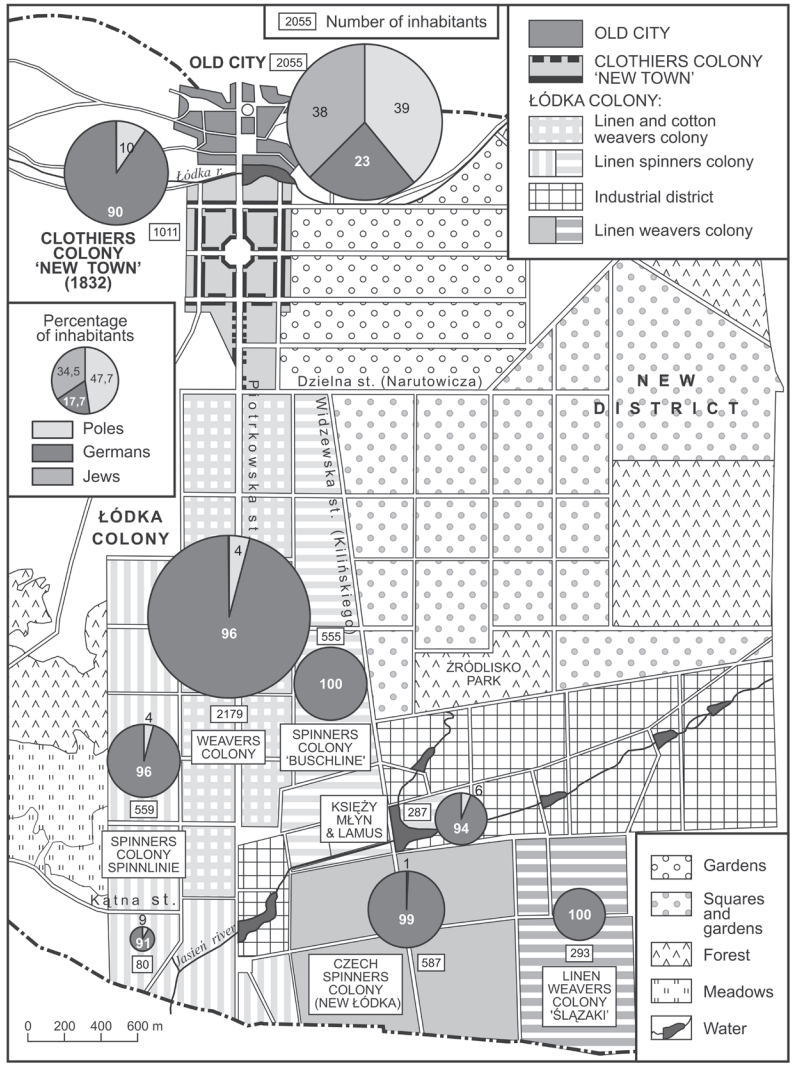

Fig. 4. Nationality structure of the population of Łódź in 1839 by districts

Source: own work based on: Kossmann, 1936, p. 30; Kossmann, 1966, p. 152; and Kossmann, 1985, p. 40.

At the end of the 1830s, a sizeable proportion, up to one-fifth, of the population of Łódź was made up of the next generation of settlers who had already been born in the city. Overall, one in three inhabitants of Łódź of German nationality had a place of birth in the Kingdom of Poland. The proportion of settlers coming from the Bohemian Sudetenland (about a quarter), Prussia (about one-fifth) and Saxony (about one-seventh) was significant. There were distinct differences in

the territorial origin of the inhabitants between the different districts – created at different times as the city developed and differing in the nature of the productive activities carried out in them. This was probably because migrants coming from a certain region and often representing similar professional qualifications often came to Łódź in larger groups. There was a large proportion of Prussians in the "New Town", while the weaving settlement had more inhabitants from Saxony (see Table 2). In the linen colony "Ślązaki" and the spinning colony "Nowa Łódka", Germans from the Czech Sudetenland dominated among the settlers, while in "Księży Młyn" and the "Lamus" area, migrants from Hesse were most numerous.

There was also a significant group of Catholics among the German immigrants settling in Łódź, most of whom were of the Protestant faith. The Catholics largely came from the Czech Sudetenland (Sudeten Germans) and settled in the south-eastern part of the "Łódka" settlement, south of the Jasień River valley, in the spinning settlement along the "Böhmische Linie" ("New Łódka"), where they made up the majority of the population in 1839. The newcomers from Silesia formed a cluster in the former Zarzew area along the so-called "Schlesische Linie" ("Schlesing"/ "Silesians") in the linen settlement, where their share of the total population reached almost two-thirds.

Table 2. Structure of the origin of the inhabitants of Łódź of German nationality in 1839 by district

District	Place of birth (%)							
	Łódź	Kingdom of Poland	Saxony	Bohemia	Prussia	Hesse	South Germany	unknown
"Old Town"	26	23	4	15	20	6	4	2
Clothmakers' settlement "New Town" – 1832	18	17	10	13	37	-	0	5
Weaving settlement	21	10	24	20	20	2	1	2
"Spinnlinie" spinning settlement	23	10	5	10	34	16	2	0
"Przy Kątnej"	20	22	7	26	18	7	-	-
"Buschlinie" spinning settlement	21	9	21	19	17	7	3	3
"Księży Młyn" and "Lamus"	24	17	3	3	16	26	5	6
Czech spinning colony "Nowa Łódka"	22	6	1	51	16	1	2	1
Linen colony "Ślązaki"	20	1	-	63	14	2	-	-
TOTAL (without "New Town")	22	11	14	24	20	5	2	2

Source: own work based on: Kossmann, 1936, pp. 35–36; Kossmann, 1966, p. 155; and Kossmann, 1985, p. 41.

The occupational structure of German immigrants settled in the cities shows their involvement primarily in activities related to the sphere of industrial production and crafts. In Lodz, the largest urban centre of the German minority, in 1851,

1,125 settler families were making a living from manufacturing activities while only seventeen were involved in trade.[23]

Already in the 1930s, with the influx of representatives of other non-textile professions to Łódź, the gradual professional diversification of the German nationality group was marked. In 1836, in addition to the guilds of clothiers and cotton and linen weavers, the guilds of carpenters, butchers, millers, bakers, tailors, and hosiery makers appeared in the register of the Łódź magistrate (Sztobryn, 1999, p. 15). Over time, the second half of the 19th century saw a declining share of the German minority in the total number of employees in the rapidly expanding industry, in which the growing demand for labour was increasingly met by an influx of workers of Polish nationality. At the same time, the proportion of ethnic Germans in the non-manufacturing sectors of the economy gradually increased.[24]

Immigration to Łódź was accompanied by the development of German education, to which the newcomers attached great importance. Between the uprisings, there were two elementary schools in the town for the children of German settlers. In 1845, a four-grade German-Russian District Real School was established in Łódź. And in 1862, two more new evangelical schools were opened (Sztobryn, 1999, p. 95-97).

In the first half of the 19th century, German settlement was a crucial element stimulating the economic development of the country and was one of the main sources of the demographic development of Central Poland and Łódź, which at that time became a thriving centre of textile production, the largest in the country.

5. GERMAN POPULATION IN ŁÓDŹ IN THE POST-UPRISING PERIOD

After the January Uprising (1863–1864), in 1865, Łódź had a permanent population of 32,400. A key component of the demographic and economic potential of this largest urban centre in Central Poland continued to be the population of German nationality, amounting to 14,400 (Janczak, 1982).[25] The proportion of the population of German origin exceeding 44% was higher than the proportion of Lutherans in the total population, since a number of members of this ethnic group were of Catholic faith (cf. Janczak, 1997, p. 44). There were four Protestant elementary schools in the town, and in 1866 the first seven-grade German secondary school was opened (Rosset, 1928, pp. 355–356).

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[23] Commercial activity was dominated by the Jewish population. See Rynkowska (ed.), 1960, p. 86.

[24] See *Statystyka zawodowa ludności Łodzi i przyległych gmin sporządzona przez prezydenta m. Łodzi Franciszka Traegera na zlecenie naczelnika pow. łęczyckiego Józefa Smarzyńskiego* for years 1851, 1853, 1855, WAPŁ 151/3906, k. nlb. [after:] Rynkowska (ed.), 1960, pp. 101–103.

[25] According to O. Kossmann, the total population of Łódź in 1864 was 33,500, with 67% (22,500) Germans, 13% (4,300) Poles and 20% (6,700) Jews (see Kossmann, 1966, p. 164).

In the initial period of the influx of German craftsmen to Łódź, the migrating craftsmen settled mainly in the newly established industrial settlements, which involved a strong spatial concentration of this nationality group. A certain weakening of the degree of spatial segregation of the German population in the urban space came in the 1840s and 1850s. At that time, in comparison with the 1830s, a slightly greater diversification of the nationality structure of industrial settlements and a more even distribution of the German nationality group were noticeable (cf. Fig. 5 and Fig. 6).

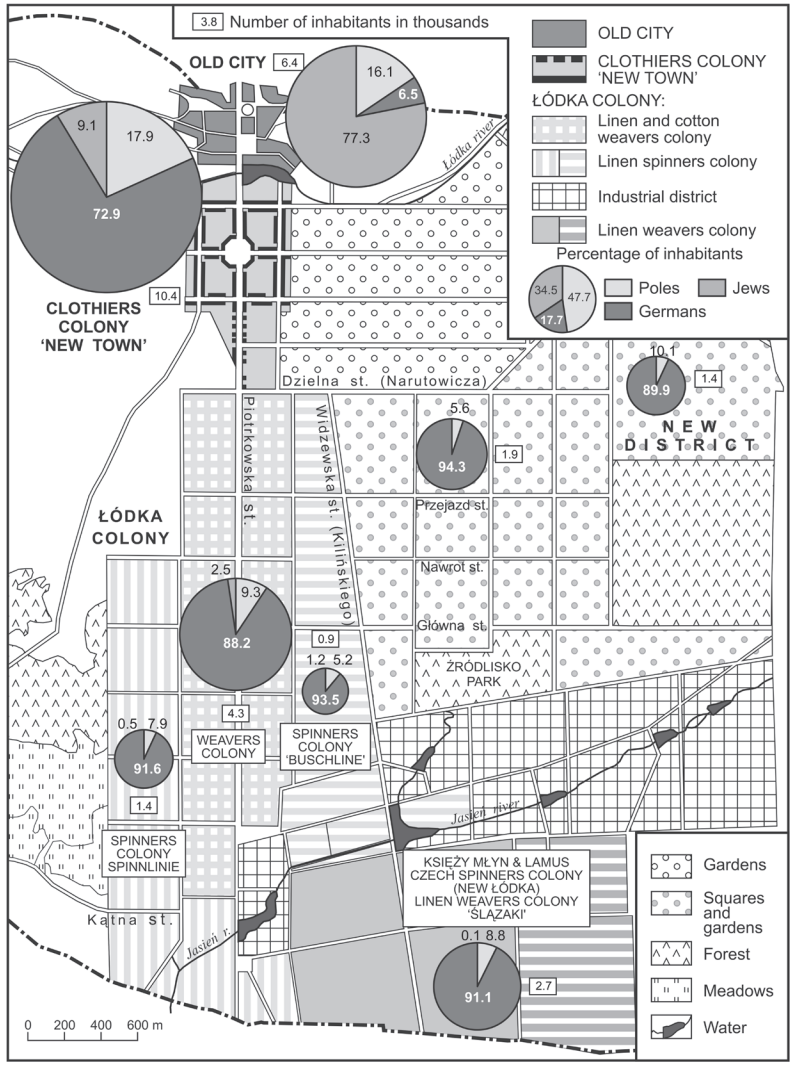

Fig. 5. Nationality structure of the inhabitants of Łódź in 1864 by district

Source: own work based on Kossmann, 1966, p. 160.

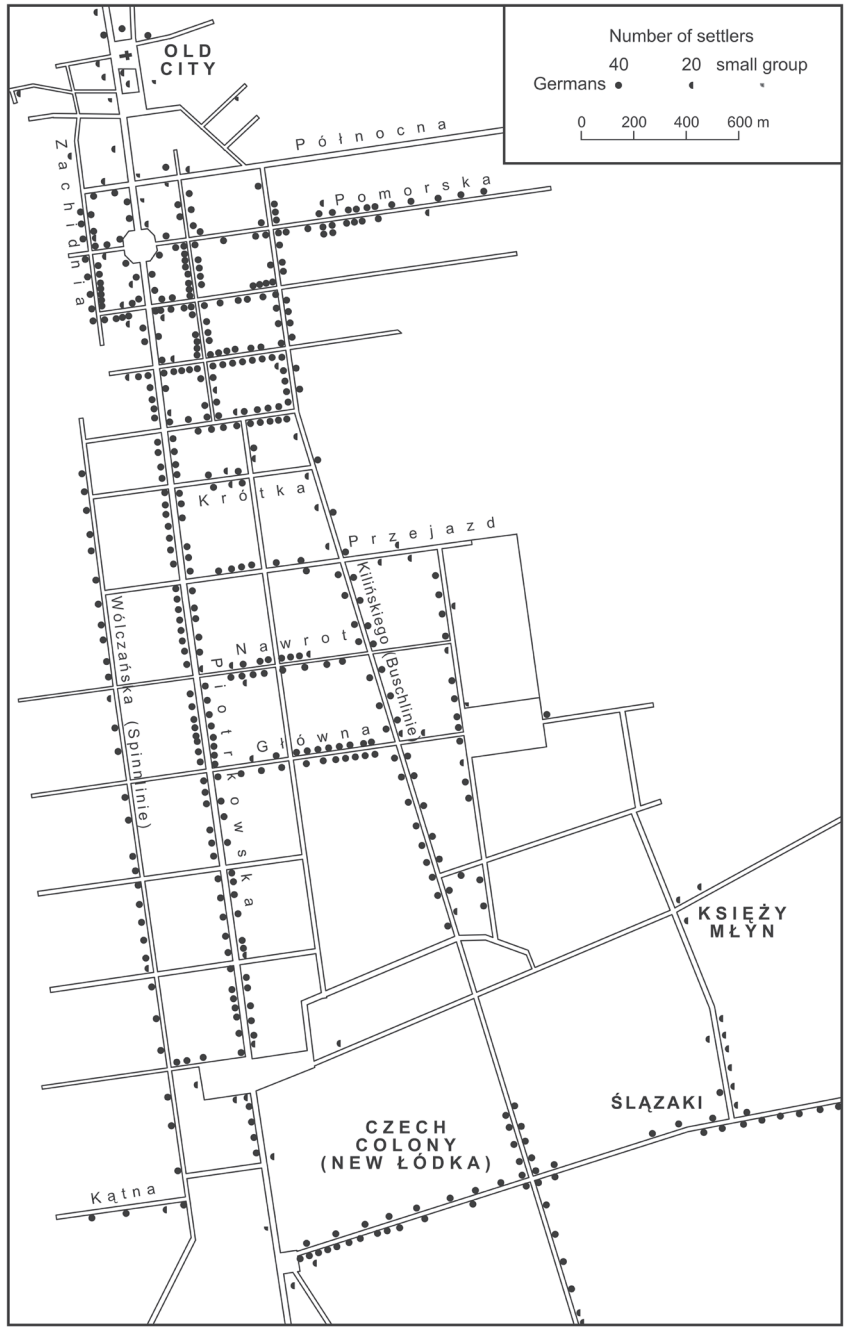

Fig. 6. Distribution of the German population in Łódź in 1864
Source: own work based on Kossmann, 1966, annex 22.

In the mid-1860s, in the "Old Town", with a population of 6,400 (more than 3-fold increase since 1839), dominated by the incoming Jewish population, Germans, whose total number remained unchanged over the past quarter of a century (400), accounted for only 6.5% of the total population. In the "New Town", despite a significant increase in the number of people of German nationality (from 900 in 1839 to 7,600 in 1864), the share of this ethnic group in the total number of inhabitants of the district gradually decreased and just after the January Uprising did not exceed three-quarters (Fig. 5). In all other districts of the city, although the proportion of ethnic Germans had also been slowly decreasing over the past 25 years (4–8%), in 1864 only one in ten people were of non-German nationality.

By the mid-1860s, more than half of the city's inhabitants of German nationality were born in Łódź, and another quarter were born in other towns in the Kingdom of Poland. The territorial origin of emigrants arriving from outside the Kingdom and living in Łódź in 1864 was dominated by newcomers from Bohemia (Sudeten Germans), with a relatively small share, compared to the 1820s and 1830s, of settlers coming from Prussia (cf. Table 3). The post-uprising period also saw a certain disappearance of the spatial segregation of the German nationality population coming from different regions in the various industrial settlements of Łódź, still quite pronounced at the end of the 1830s.

Table 3. Origin of Łódź's inhabitants of German nationality in 1864 by district (based on analysis of about two-thirds of the total German population in Łódź)

District	German population (%)		Immigrants from (%)				
	born in Łódź	immigrants	Kingdom of Poland	Saxony	Bohemia	Prussia	other and unknown
"Old Town"	57	43	58.5	2.8	8.5	20.8	9.4
Clothmakers' settlement "New Town"	55	45	54.8	9.4	10.0	18.3	7.6
Weaving settlement	58	42	46.6	14.9	14.7	15.2	8.7
"Spinnlinie" spinning colony	56	44	42.6	10.6	11.5	20.5	14.8
"Buschlinie" spinning colony	55	45	43.3	15.2	21.7	12.0	7.8
Czech spinning colony "Nowa Łódka", linen colony "Ślązaki", "Księży Młyn" and "Lamus"	58	42	41.2	5.2	32.0	13.7	7.9
"New Quarter"	53	47	47.1	14.8	15.0	12.2	10.8
Krótka (now Traugutta), Przejazd (now Tuwima), Nawrot, Główna (now Piłsudskiego) streets	57	43	46.6	14.4	19.8	12.2	7.1
TOTAL (without New Town)	56	44	49.1	11.1	15.1	16.1	8.6

Source: Kossmann, 1966, p. 155.

During the final three decades of the 19th century, the number of people of German nationality in Łódź doubled, also as a result of the population flow from neighbouring industrial centres. At the same time, the proportion of this ethnic group in the total population of the rapidly growing city saw a sharp decline. Data from various sources give rather different estimates of the German minority in Łódź at the turn of the 19th century. The government census carried out in 1903 showed 90,800 people of German nationality, i.e., 28% of the total population (313,100).[26] However, according to the 1911 census, the number of people of German nationality in Łódź amounted to approximately 80,000 (*Informator Miasta* Łodzi, 1918, p. 25). These figures do not quite correspond with the data presented in Fig. 7 (in the author's opinion the most reliable), according to which just before the outbreak of First World War Łódź was inhabited by 105,500 people of German nationality, which accounted for slightly more than one-fifth of the city's population.[27] These discrepancies, as far as they are within certain limits, should not be surprising in light of the impossibility of establishing an objective criterion of nationality.

In the post-uprising period, as a result of a massive influx of Polish (mainly rural) and Jewish (from western Russian governorates and small towns in the Kingdom of Poland) inhabitants to Łódź and the gradual process of polonisation of some newcomers from across the western border of the Kingdom of Poland, the proportion of the German minority in the total population of the city decreased (cf. Fig. 7). The German population, which had been the dominant national group since the time Łódź was transformed into a factory town until the January Uprising, steadily decreased its share of the city's demographic potential in the following decades and by the outbreak of the First World War accounted for only about a quarter of the city's population.

Despite a decrease in the share of the German population in the total number, the development of industrial Łódź in the last decades of the 19th century was linked to the key role of this ethnic group in the city's economic potential.

In 1865, among the 388 owners of Łódź industrial plants, centralised manufactories and craft workshops employing more than five people, as many as 245 (63.4%) belonged to people of German nationality (cf. Table 4). In the 1880s and 1890s, the percentage of ethnic Germans among Łódź entrepreneurs was around 53–57% and only dropped to 44% before the outbreak of First World War. While Jews prevailed among the petty bourgeoisie, people of German nationality were far more numerous among medium-sized and especially large entrepreneurs, as

[26] According to this census, there were 143,700 Poles and 78,600 Jews (Korzec, 1956, p. 31).

[27] An underestimated size of the German population in Łódź in 1913 is given by W. L. Karwacki – 75,000, i.e.. 14.8% of the city's population (Karwacki, 1972, p. 8). However, a clearly overestimated number is given by J. Śmiałowski, who wrote that in 1913 172,000 inhabitants of the city declared that they belonged to this nationality (Śmiałowski, 1999, p. 221).

well as in all non-textile branches of industry.[28] Significantly, Łódź's industrial plants were among the most technically and organisationally advanced in the Russian Empire.

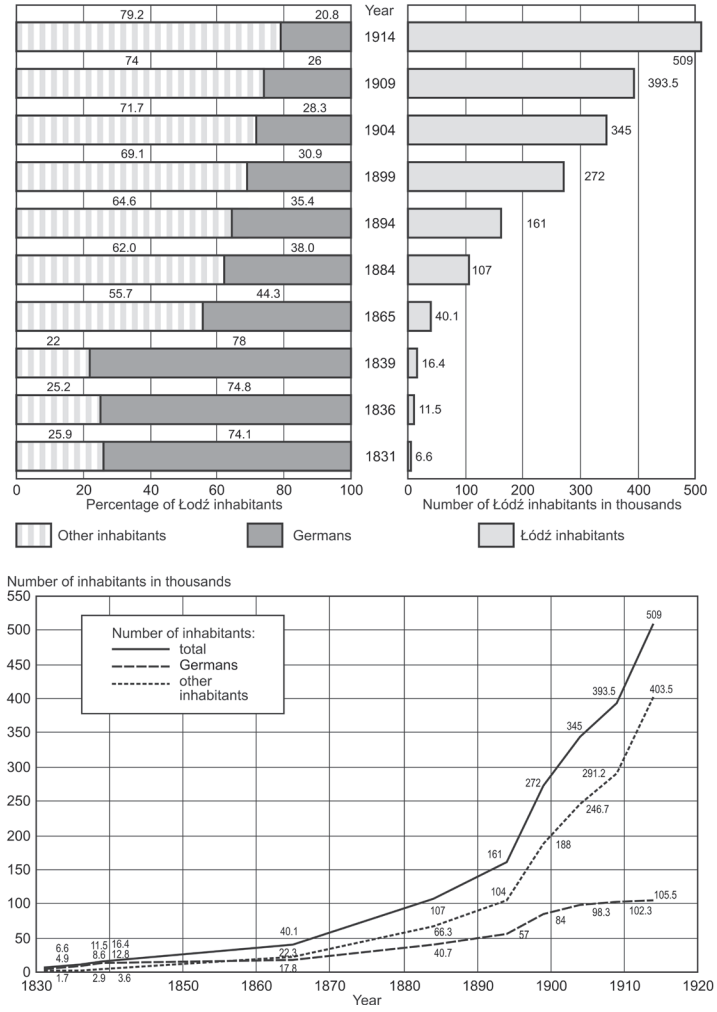

Fig. 7. Population of German nationality in Łódź 1831–1914

Source: own elaboration based on: *„Pierwaja wsieobszczaja pierepis…"*, 1905, pp. 246–247; Janczak, 1982, pp. 108–109; Kossmann, 1966, p. 158.

[28] Detailed data on the size of establishments operated by German entrepreneurs can be found in S. Pytlas, 1991, pp. 63–67. At the beginning of the 20th century, among Łódź's nine largest enterprises, six belonged to German industrialists: K. Scheibler (7,400 workers), Heitzl-Kunitzer (2,800), L. Geyer (2,700), J. Heinzl (1,700), and L. Grohman (1,200) (see Koter *et al.*, 2005, p. 46–47).

Table 4. Number and share of industrialists of German nationality in Łódź industry 1865–1913

Year	Industrialists of German nationality				Industrialists total	
	Textile industry		Other industries			
	number	%	number	%	number	%
1865	242	62.4	3	0.8	388	100
1869	185	58.4	3	1.0	317	100
1879	126	42.0	21	7.0	300	100
1884	101	46.3	23	10.6	218	100
1893	158	36.3	75	17.2	435	100
1900	207	32.0	120	18.5	648	100
1904/1905	246	22.5	222	20.3	1093	100
1910/1911	282	25.7	214	19.5	1097	100
1913	306	24.5	242	19.4	1247	100

Source: Pytlas, 1991, p. 57.

In 1897, more than one in four people employed in industry and crafts in Łódź were of German nationality. There was an even higher proportion of people of German origin among those living on income from capital and related sources, and a slightly lower proportion among those living on state funds (Janczak, 1982, pp. 159, 163-166). According to the 1897 census, 73% of the population of German origin in Łódź made their living from industrial and craft occupations, 8% from trade, and 10% from serving others and other professions (Janczak, 1997, p. 66; Janczak, 1991, p. 50). The employment of representatives of the German minority in clerical and administrative positions was relatively low, compared to other large cities in the Kingdom, due to the weakness of the administrative and cultural functions of this eminently industrial city. Compared to other national groups, German population was relatively the best educated – in Łódź, the literacy rate in this ethnic group in 1897 exceeded 59% and was much higher than the average 50.5% for the entire population of the city's inhabitants.[29]

The beginning of the 20th century, with the deterioration of working conditions, brought the emergence of economic tensions. Strikes began to break out in numerous factories in the Russian partition in 1905. The unrest also extended to Łódź, where strong social tensions had clear national connotations. Of great importance was the fact that the economically strongest nationality group was the Germans, involved in industrial activities. In 1913, 27 joint-stock companies (only one Polish), ninety-five factories (10 Polish) and 251 trading companies

[29] According to the 1897 census, only 48% of Poles and 47% of Jews could read and write.

(125 Polish) remained in the hands of this ethnic group in Łódź. Persons of German nationality owned 1,422 properties (while Poles held titles to 700 properties) (Karwacki, 1972, p. 9). Of the fourteen largest businesses operating in Łódź in the early 20th century, ten were German-owned (see Kessler, 2001, p. 18). Of just over 1,000 foremen and skilled technical staff in the Łódź textile industry, two-thirds were of German nationality.[30] This structure of capital and employment in Łódź and the region was determined by the dominance of textile industry, in which newcomers from across the western border of the Kingdom of Poland had been involved for generations.

6. SOCIAL INTEGRATION AND ASSIMILATION PROCESSES OF THE GERMAN MINORITY

Among the German immigrants, there was a clear tendency towards separation in the sphere of professional and social activities, which was manifested, among other things, in the reluctance to join existing Polish-Catholic associations and craft guilds. Where settlers formed sufficiently strong concentrations, as in Łódź, they established their own German organisations.[31] This led to the formation of a kind of professional ghetto, to some extent isolated from Polish society and characterised by cultural, linguistic and religious distinctiveness.

A gradually developing school system for the children of German settlers helped to maintain a sense of national identity. A network of Protestant religious schools with German as the language of instruction was developing, often without Polish as part of their curriculum.[32] The assimilation processes were counteracted by the religious separateness of the dominant part of the German settlers belonging to the Evangelical Church of the Augsburg Confession.

During the pioneer period, which lasted until the end of the third decade of the 19th century, assimilation processes occurred to a limited extent – especially where the German minority formed larger clusters – and affected a small number of people. Rather, these were times of adaptation of the German community to

[30] Poles made up about a quarter of this professional group (Kessler, 2001, p. 18).

[31] The first association formed in Łódź in 1824 was the "Lodz Rifle Association" ("Lodzer Bürger Schützen-Gilde"), also known as the "Marksmen's Society" or "Bractwo Kurkowe". In 1825, the "Foremen's House" ("Meisterhaus") was opened in Łódź and became the centre of the settlers' social life. The guild of clothiers was established, soon followed by the guild of cotton and linen weavers (Budziarek, 2001, p. 53).

[32] In 1826, a class for children from German families was established in the existing elementary school in Łódź and a teacher who spoke German was employed. In 1829 a second elementary school was opened in the cotton and linen settlement "Łódka", and in 1834 an Evangelical elementary school was established (Podgórska, 1988, p. 509).

the new, and rapidly changing, living conditions in their new place of settlement (Pytlas, 1996, p. 14). Over time, the process of social integration has gradually become more pronounced in successive generations of migrants, with a growing sense of rootedness in the new place of settlement in part of the German population. The assimilation of the German population, which slowly progressed during the inter-uprising period, also in Łódź, clearly slowed down in the mid-1860s.

Growing unemployment among workers and the increasing emigration of the Polish population to Western European countries to find jobs contributed to the emergence of certain national tensions in the 1870s and 1880s also in the industrial centres. In Łódź, antagonism gradually grew between some of the German factory owners, who, with the permission of the imperial authorities, employed workers imported from Germany, and the impoverished Polish population.

The polarisation of national attitudes was reflected in the fact that people of German nationality were favoured in the selection of personnel for the more attractive factory positions.[33] On the other hand, Polish employees were ill-disposed even to situations where the filling of a position by a person of German nationality was entirely justified by professional qualification needs. The increasing influx of immigrants into Łódź industry in the late 1870s and early 1880s clearly weakened the ongoing assimilation processes of the German minority. The newcomers, unlike the earlier settlers, were not inclined to learn Polish, nor did they feel the need to integrate with the Polish community.[34] Barriers of a socio-economic nature as well as differences resulting from religious beliefs were factors slowing down the process of Polonisation (Falęcki, 1996, p. 78).

With its population dominated by immigrants, without any significant cultural traditions or historical heritage that could have fostered the integration and assimilation of newcomers from abroad, Łódź was quite unique in terms of the ongoing integration and assimilation processes of the German minority. Initially, the predominance of recently settled people of German nationality in the city, together with the lack of Polish intelligentsia, encouraged people to close themselves within their own ethnic circle. It was not until the last forty years of the 19th century that the percentage of German inhabitants in the rapidly expanding Lodz decreased significantly. However, the multinational character of the city with a growing number of inhabitants of Polish nationality only accelerated the Polonisation processes to a certain extent, as the Łódź bourgeoisie, largely of German nationality, showed weak ties with Polish culture, and the city itself remained on the margins of Polish culture until the outbreak of World War I, which did not create a climate conducive to assimilation processes (cf. Nietyksza, 1986, pp. 306–308).

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[33] In 1889 there were only 10% of Poles among the foremen in Łódź (Missalowa, 1964, pp. 81–88; and Missalowa, 1967, p. 83).

[34] 'O prawdę', *Dziennik Łódzki*, 1885, no. 214 [after:] Pytlas, 1996, p. 16.

In a situation where the German community was dominant, the attraction of the culture, language and customs of this ethnic group for large sections of the population of other nationalities grew. The activity of bourgeoisie of German nationality in the cultural field was crucial. As early as the 1850s, amateur theatre groups were active.[35] The preservation of the language and culture of their country of origin was helped by the activities of numerous German singing associations.[36] In 1906, the Association of German-speaking Foremen and Workers was founded in Łódź, followed in 1907 by Łódź School and Educational Society (Radziszewska and Woźniak, 2000, pp. 46–70). From the point of view of the preservation of German culture and language, important support came from the press, whose first German-language titles appeared in Central Poland in the last decades of the 19th century.[37]

These measures aimed at preserving the language and native culture of the German minority, while undoubtedly delaying, could not stop the processes of assimilation and Polonisation, which were becoming increasingly pronounced over time, especially among earlier settlers who had managed to grow attached to their country of settlement.

Among the multi-ethnic community of Łódź, ethnic diversity and a sense of nationality were generally not a source of major dilemmas. All were citizens of the Russian Empire for whom Russian was the official language (from 1865 onwards) and, regardless of their origins and the language they used at home, they had a fairly limited sense of connection with their own national culture, feeling themselves to be primarily members of local communities. The German population did not so much feel a connection to an ideological homeland, but above all identified with the environment of their place of residence, settlement, town or region. For the most part, these were people who could hardly be considered assimilated, but who, while not completely renouncing their national identity, at the same time tried to be loyal to Polish society.

At the end of the nineteenth century quite a numerous group of non-Polonised people of German nationality emerged, mainly from the metropolitan business community, with a loyalist attitude to every authority. For this group, a sense of nationality was of secondary importance, and the key issue was the possibility of doing business.[38]

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[35] In 1855, an association called "Gesellschaft Thalia" was established in Łódź, which gave a performance every Sunday, alternating between German and Polish (Kuligowska-Korzeniewska, 1997, p. 242).

[36] Among others, Łódź saw the emergence of Men's German Singing Society (1846), the Church Singing Society "Cecylia" (1856), the Singing Society at the Trinity Church (1859), the United Society of German Singers at St John's parish (1884) and the Bałuty Singing Society (1898).

[37] From 1863, the "Lodzer Anzeiger" ("Łódź Announcements") was published, soon transformed into the German-language magazine "Lodzer Zeitung". From 1881 to 1905, the "Lodzer Tageblatt" was published (cf. Jaworska, 1988, p. 553). For more on the German press in Łódź, see Kucner, 2001, pp. 209–234.

[38] This group was referred to as "Rubelpatrioten". Cf. Eichler, 1921, p. 119.

This phenomenon at the beginning of the 20th century was particularly evident in Łódź which

> despite being neither a country nor a state, has its own nationality – these are called 'Lodzermenschen' in German. Their original homeland was Germany; their prolonged residence in our country for several generations eventually transformed their Germanic patriotism but did not attract them to Polish nationality. These people are mostly politically unprincipled – they have found their homeland in Łódź, here they have earned their living and their positions, they have become attached to the city ... among many of these 'people of Łódź' a turn towards assimilation with us can be observed, and the children of 'Lodzermenschen' sometimes openly call themselves Poles already (Górski, 1904, pp. 21–24).

At the turn of the 19th century, the German community settled in Łódź was truly diverse in terms of its sense of nationality. In addition to a certain part of it, especially older immigrants in the following generations, who had already been Polonised, there was also no shortage of people declaring their German nationality (and among them also germanised Poles and germanised Jews) as well as those undecided about their nationality (Górski, 1904, p. 22, 24). And although it is difficult to speak of advanced processes of Polonisation among the entire ethnic German community, most of them were well integrated into the social environment of the city.

7. FINAL REMARKS

The German settlers arriving in Łódź in the 19th century made an unquestionable and very significant contribution to the development of the city. The influx of professional labor force of German origin determined the development of the textile industry in Łódź. The settlers coming from abroad were characterised by the typical Protestant diligence and thriftiness, sense of responsibility and respect for work. The tendency to invest at the expense of limiting current consumption facilitated adaptation to a new place of residence and was particularly important in the period of accelerated industrialisation. Over the course of several 19th-century decades, Łódź grew from a small, neglected settlement into the main urban centre of Central Poland and the largest concentration of textile production on Polish territory.

At the beginning of the 20th century, Germans involved in industrial activities were the economically strongest national group in Łódź. Most of the joint-stock companies, factories, trading companies and real estate remained in the hands of this ethnic group. The German-speaking population constituted the majority of qualified technical personnel in the textile industry of Łódź.

When Poland regained independence in 1918, the role of the German minority in the city's demographic and economic potential was somewhat

limited. The population of German origin in the interwar period, numbering about 50,000–60,000 people (about 10% of the city's population), still had a significant influence on the development of Łódź, and most of the owners of large production plants had German roots. There was a strong concentration of this national group south of the Łódka River (where industrial settlement had already begun in the first half of the 19th century), especially in the southern part of the city center.

The Second World War brought radical transformations in the national structure of the inhabitants of Łódź, once a city where three nationalities (Polish, German, and Jewish) lived side by side for a century and a half, resulted in. The extermination of the Jewish population and the escape and displacement of the German population resulted in the city becoming mono-national. The second half of the 20th century – a period of communist rule in Poland and the related historical policy – was not conducive to maintaining the multinational heritage of Łódź.

The situation changed significantly after 1990, with the democratisation of life in the country and local governments independence. The past three decades have seen attempts at restoring the memory of the achievements of German settlers and their role in the development of Łódź. This role is documented by the heritage left behind, visible in the contemporary structure of urban space – Evangelical cemeteries, factory buildings, factory owners' palaces, and buildings of German financial and educational institutions. The contribution of the German minority to the development of the city, which was repressed from social consciousness in the first post-war period, is now being recalled again, which can be seen, for example, in the concern for the relics of the post-German cultural heritage, or in the sphere of toponymy – many streets and objects of the rapidly revitalising city space recall the memory of its distinguished citizens of German origin. Łódź, today devoid of German and Jewish inhabitants, due to its heritage still remains a multicultural city.

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SPATIAL MATCHING OF EMERGENCY SHELTERS TO THE DISTRIBUTION OF RESIDENTS IN THE LIGHT OF TRANSPORT BEHAVIOURS OF EVACUEES DURING WAR: THE CASE OF SUWAŁKI

Abstract. The aim of the article was the assessment of the spatial matching of existing shelters (supply) to the distribution of residents in Suwałki (demand), considering their declared transport

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behaviours while evacuating during war. The analysis was conducted based on the locations of existing emergency shelters using data on population distribution (registration data with building accuracy). Spatial alignment was determined using the P-Median problem and E2SFCA. In terms of establishing vehicular or pedestrian travel time, the Manhattan metric based on the urban road network model was utilised. A model of vehicle movement speed was then constructed, while a constant speed was assumed for pedestrian movement. Additionally, survey data on the transport behaviour of inhabitants of Suwałki in the case of war were conducted in 2023. The study concluded that the population residing within the city limits should evacuate on foot, and that prior training on the evacuation process is especially necessary for those who reside in less populated areas of the city. The analyses also showed that existing emergency shelters are overly dispersed, making management difficult for emergency services. Since the current capacity of emergency shelters is not sufficient for the number and distribution of inhabitants of Suwałki, the most practical significance of this article in this respect is to indicate to the authorities the optimal number and location for emergency shelters (to improve the evacuation process).

Key words: emergency shelters, evacuation, transport behaviour, war, Suwałki Gap, surveys.

1. INTRODUCTION

In the face of escalating global conflicts, the protection and safety of civilians have emerged as primary concerns, necessitating innovative approaches in disaster management. The ongoing warfare between Russia and Ukraine has dramatically underlined this reality, casting a harsh spotlight on the inherent limitations and fragility of international laws and conventions during crisis situations. Urban areas have borne the brunt of this conflict, with inhabitants seeking refuge in hastily designated emergency shelters. This stark reality underscores the pressing need for analyses aimed at appropriately preparing cities for passive defence. It calls for comprehensive planning and strategic allocation of emergency shelters for civilians to mitigate the potential devastating impact on both population and property (Bayram, 2016).

In the realm of disaster management, evacuation has long been considered the cornerstone of efforts aimed at protecting people from various calamities, including war (Jha *et al.*, 2004; Na *et al.*, 2012). The main objective of evacuation is to provide safe and efficient means to move people away from areas of immediate danger to designated safe zones following a disaster.

Evacuation planning is an intricate process designed to minimise casualties and property damage resulting from disasters, including war (Jafari *et al.*, 2005). A critical element of this planning involves understanding the spatial mobility of civilians, particularly in relation to the evacuation process during conflict. This process is essential for two key reasons. Firstly, it educates individuals on the steps they need to take to evacuate efficiently and systematically, thereby increasing their chances of survival. Secondly, it provides a valuable roadmap for im-

provements to be made in crisis management plans, potentially leading to more effective evacuation procedures (Stepanov and Smith, 2009; Borowska-Stefańska *et al*., 2023).

Efficient supply and demand management strategies are crucial for effective evacuation planning and management. The spatial distribution of the existing emergency shelters is directly linked to a city's ability to withstand disasters. Therefore, it is necessary to conduct a comprehensive assessment of the distribution of such shelters to ensure an effective response to disasters. Previous literature has analysed evacuation management in terms of supply and demand. Analyses for this purpose have primarily used information on the population and the capacity of evacuation points. Kulshrestha *et al.* (2011) presented a robust approach to determining the optimal locations and capacities of public emergency shelters. They addressed the uncertainty of demand with respect to the number of evacuees (these studies do not consider the more realistic consideration of the travel choices of evacuees). Zhu *et al.* (2018) proposed a supply-demand relationship by dividing emergency shelter capacity by the total number of evacuees, using the two-stage floating catchment area (2SFCA) method. However, their study showed that the ability of those affected to evacuate to the nearest shelter was limited. This method has been used in the literature to study the accessibility of urban public amenities, such as hospitals (Nakamura *et al*., 2017; Borowska-Stefańska *et al.*, 2017), but they have been underutilised in the examination of the accessibility of emergency shelters.

Previous research has focused on analysing the behaviours of populations during evacuation processes, particularly in relation to natural disasters (Borowska-Stefańska and Wiśniewski, 2018; Fei *et al.*, 2023; Geng *et al.*, 2023). The literature lacks data on the transport behaviours of populations during war and its use in planning the evacuation process. This study contributes to this area. In addition, this is the first study of this type for Suwałki – an important place in the context of a potential war due to its geographical location. War presents unique challenges, which means a bespoke approach is required, highlighting the necessity of research in this area. Borowska-Stefańska *et al.* (2024) examined the transport behaviour of people in four cities (and four countries) affected by war. The research showed that when the inhabitants of these cities wanted to evacuate, they were generally not familiar with evacuation instructions and did not know where emergency shelters were located. In order to properly plan the evacuation process, it is not only important to know the behaviour of the residents, but also to educate them in this regard (Borowska-Stefańska *et al.*, 2024).

The aim of this article is the assessment of the spatial matching of existing emergency shelters (supply) to the distribution of residents in Suwałki (demand), considering their declared transport behaviours while evacuating during war. Effective evacuation planning requires matching shelter capacity to demand in different spatial segments of the city. In order to ensure optimal performance, it is

important to not only provide an adequate number of emergency shelters, but also to carefully consider their location in relation to the populations they serve (Huang *et al.*, 2016). Studies have shown that improper planning in this context can lead to severe congestion and delays, significantly affecting the overall efficiency of the evacuation (Sorensen, 2000). The study's innovative stance lies in its commitment to employing a methodological and applied approach. It emphasises the adaptation of elements of spatial development, particularly emergency shelters, to the unique needs presented by the evacuation process. While this research carries global implications, its relevance is especially salient for European countries, particularly those belonging to NATO. It proposes that with the use of comprehensive data and the suggested methodological approach, we can enhance the evacuation process during war. This enhancement would involve the appropriate preparation of both public bodies and residents, along with the optimal placement of emergency shelters. The ultimate goal is to ensure that evacuation during times of crisis is not just a reactive process, but a well-prepared strategy designed to save lives and minimise damage. Through informed decision-making and comprehensive planning, this study illuminates the path towards not just survival, but resilience in the face of war, setting the stage for the robust discussions and analysis that follow.

The manuscript unfolds over six sections. First, an introduction establishes the context and issues to be discussed. Second, a comprehensive review of the theoretical background aligns the study within the wider academic discourse, highlighting contrasting views on disaster management and evacuation planning. The third section provides a detailed exploration of the research area, the Suwałki region, revealing its unique geographic, social, and political characteristics. In the fourth section, the adopted materials and methods are meticulously detailed, explaining how the location of emergency shelters and population data were utilised, and how evacuation was simulated. The fifth section presents and discusses the study results, focusing on the optimal location of emergency shelters and evacuation strategies. The final section concludes the study, summarising key findings and contributions, identifying potential research limitations, and outlining future research avenues.

2. THEORETICAL BACKGROUND

About 3.3 billion of the world's population live in suburban or urban areas, with prospects that this will grow to over 5 billion by 2030 (NRC-Urban-Shelterguidelines_23-11-10_compressed, n.d.). This rapid and uncontrolled urbanisation process, combined with other phenomenon like migration, conflicts, and disasters (natural or man-made) will amplify the human crisis, challenging the fragile ur-

ban ecosystems and the sustainable development process, impacting, at the same time, urban economic, social, and environmental health security. In this context, to be able to address conflicts, crises or disasters, cities must be equipped well, aware that a well-planned, self-motivated evacuation greatly reduces damage and casualties. Cities must provide protection and coping mechanisms, as the number of people seeking shelter in urban areas will continue to rise (Luo, 2019). The process of evacuation can be divided into five stages: the decision to evacuate; warning; escape; shelter; and return (Lim *et al*., 2013).

The first three stages of an evacuation are critical. Delays in any of these may result in insufficient time to conduct the planned evacuation, i.e., a situation where not all evacuees reach the desired destination in good time, or even fail to escape the danger areas (Urbina and Wolshon, 2003; Jonkman, 2007; Kolen and Helsloot, 2012; Kolen *et al.*, 2013). A key objective of planning an evacuation in emergency situations is to ensure that evacuees leave the affected area as quickly as possible and reach safe locations. Therefore, planning an evacuation should be about minimising the total evacuation time, thereby protecting the health and lives of the population (Dulebenets, 2021).

Evacuation may be classified as voluntary, recommended, and mandatory. No special traffic-related controls or transportation measures are normally taken during voluntary evacuations, people in such cases can even remain in their places of residence if they wish. Recommended evacuation refers to disasters with a higher probability of endangering the population. In this case, decisions of whether or not to leave are left to individuals and limited emergency transportation arrangements are made. Mandatory evacuations represent the most serious type of evacuation, but they are extremely difficult to conduct and, in many countries, are even impossible since relevant provisions do not exist everywhere and people often resist orders to leave their homes (Urbina and Wolshon, 2003).

Moreover, it is important whether an evacuation is conducted (supervised and controlled) by an external entity (emergency services in particular) or by the evacuees themselves, in which case it is called self-evacuation (Kolmann, 2020) and may be performed in an organised manner or spontaneously (Gromek and Kozioł, 2015). Spontaneous self-evacuation happens when there is a direct threat of disaster. A planned (organised) self-evacuation can be implemented before a catastrophe when the probability of a disaster is high. In such situations, people should immediately evacuate to a secure location, utilising their own transportation. Most often, residents will use their own modes of transportation, but if a household does not have access to a car or other means of transportation, a neighbour may be willing to provide assistance. That being said, it is essential to emphasise that the success of self-evacuation depends largely on the individual's resources, including access to transportation and a place of refuge. The primary difference between self-evacuation and coordinated evacuation is that self-evacuation is not managed, supervised, or controlled by authorities, resulting

in a spontaneous and unorganised approach that may become chaotic due to poor information and knowledge (Kolmann, 2020). It should also be noted that evacuation may be by vehicular transport, on foot or a combination of the above. Were evacuation transport employed by the organisers of an evacuation, it will primarily be for people unable to evacuate themselves – highlighting the need to know the community in the area. The use of vehicular transport, particularly road and rail, is essential for the organised movement of large numbers of people (or other entities) to be evacuated over longer distances. However, these means of transport are often not available in sufficient numbers to fully meet the needs in question. Therefore, in such cases, a combined method enables the use of available means of transport of an organised nature together with the evacuees' own resources or the use of escape on foot. From the perspective of decision-makers responsible for evacuation management, each of these options has their limitations, which affect the validity, efficiency, and effectiveness of their application (Kolmann, 2021). A number of decisions must be made at the individual level about whether to evacuate, when to evacuate, what to take with, how to travel, what route to travel, where to go, and when to return (Alsnih and Stopher, 2004). As part of an evacuation, the following behavioural analysis questions need to be addressed: (1) how many people will evacuate (evacuation participation rate); (2) at what point residents will evacuate in relation to an evacuation order; (3) what usage rate can be expected for public emergency shelters; (4) how many resident will evacuate to points further afield; (5) how many of the available evacuation vehicles will be used.

City emergency shelters play an important role in protecting people during war, which is why a few important points should be considered regarding their location:

– City emergency shelters should be planned based on their optimum situation for the population using them. Access to these shelters should be devised in such a way that they can accommodate large numbers of people in emergency situations as rapidly as possible.

– Shelters should also be useful in times of peace. Therefore, public service facilities should be planned as shelters, offering protections for citizens during and after disasters.

– In order for residents of cities to access their nearest emergency shelter in case of war, they should be informed of the exact location of said shelters (Shakibamanesh and Fesharaki, 2011; Zhu *et al*., 2023).

In order to obtain all information for planning the evacuation process, it is necessary to know the potential transportation behaviour of residents in affected areas, as well as to be aware of designated shelter locations, to establish evacuation routes, and to determine the number of services participating in these activities (Borowska-Stefańska *et al*., 2024).

3. CHARACTERISTICS OF THE RESEARCH AREA

Suwałki is located in northeastern Poland, near the borders with Lithuania, Russia, and Belarus (Fig. 1). It is the second largest city in the Podlaskie Voivodeship. Transport routes from Berlin (via Warsaw) to St. Petersburg and from Warsaw to Helsinki (the Via Baltica and Rail Baltica routes, which connect the Baltic countries with Western Europe) go through the city. The Suwałki Gap links the Baltic states with Poland and the other NATO countries, while separating Russia's Königsberg region from Belarus (an ally of Russia). It is, therefore, a strategic location in any potential escalation of the current war beyond the territory of Ukraine. Traffic in Suwałki is largely on a radial road system (with not very high technical parameters), as the outer ring road is not fully closed (Fig. 9).

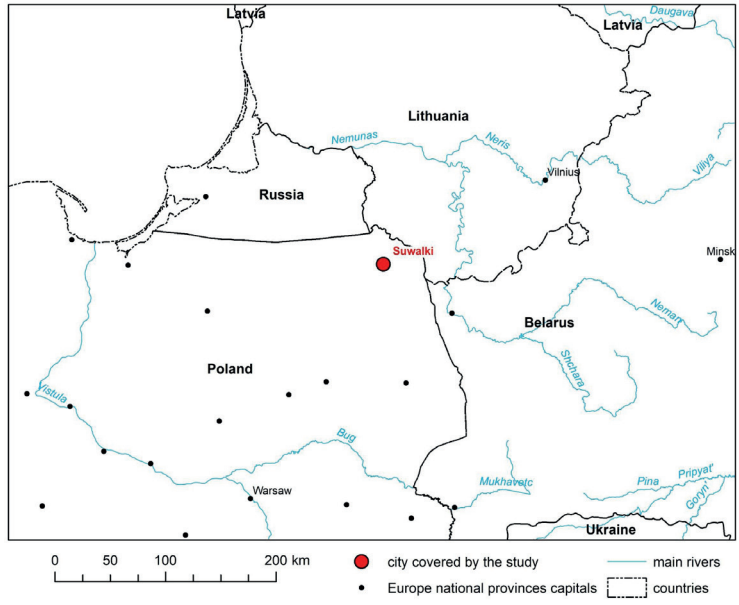

Fig. 1. Location of Suwałki

Source: own work.

Thanks to information obtained from the Suwałki City Hall staff, a total of 8 documents related to the emergency response criteria that the city uses have been identified. 6 of these cover the local level, two of which relate to the operation and organisation of the City Hall itself. The other are plans for crisis management; evacuation and reception of the population; civil defence, and the functioning of the city of Suwałki in a situation of external security threat and war. No documents were identified at the regional level (Table 1).

Table 1. Documents related to emergency situations used by the city of Suwałki

National level	Local level
– Guidelines of the Chief of National Defence of 17.10.2008 on the evacuation of population, animals and property in case of a mass emergency – Instruction on the principles of evacuation of population, animals and property in case of a mass emergency	– Municipal Crisis Management Plan (2022) – Evacuation/Reception Plan for the Population in the City of Suwałki (2021) – Civil protection plan 2012/2022 – Operational plan for the functioning of the City of Suwałki in conditions of external threat to state security and war (2021/2022) – Organisational Regulations of the Town Hall in time of war (2022) – Plan for the technical adaptation of the Town Hall to a command post or relocation at an alternate place during an external threat to security and in time of war, or in the event of any specific threats making it impossible to continue operations at the current location

Source: own work.

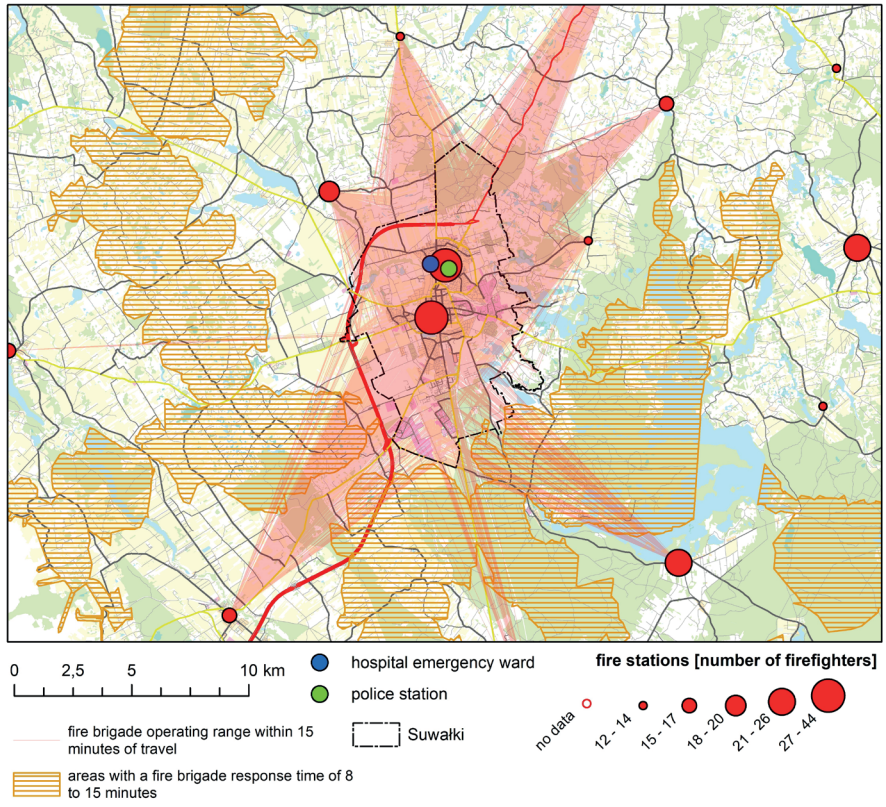

Fig. 2. The location of the city of Suwałki in the supra-local perspective against the background of the spatial range of services provided by the fire brigade

Source: own work.

In Poland, the State Fire Service (SFS) (a professional body established to fight fires, natural disasters, and other local hazards) plays a key role in rescue and civil protection. In the rescue and civil protection subsystem, the SFS is supported by other emergency services, state institutions and NGOs. The SFS, however, most closely collaborates with the Voluntary Fire Service (VFS). As of 31 May 2021, there were two emergency and firefighting units in Suwałki with approximately 70 staff (Fig. 2). This number, however, is insufficient should the need to protect the residents of the city of Suwałki against a major incident arise. These units would then need to be reinforced by firefighters from local VFS stations.

The data retrieved from the Town Hall of Suwałki shows that, as of 19 April 2023, the town had 66,838 residents, including 926 people on temporary stay visas (Table 1). Figure 3 (left) presents the distribution of the town's population, whose pattern of distribution is shaped by a north-south axis, with a particularly high density in the north.

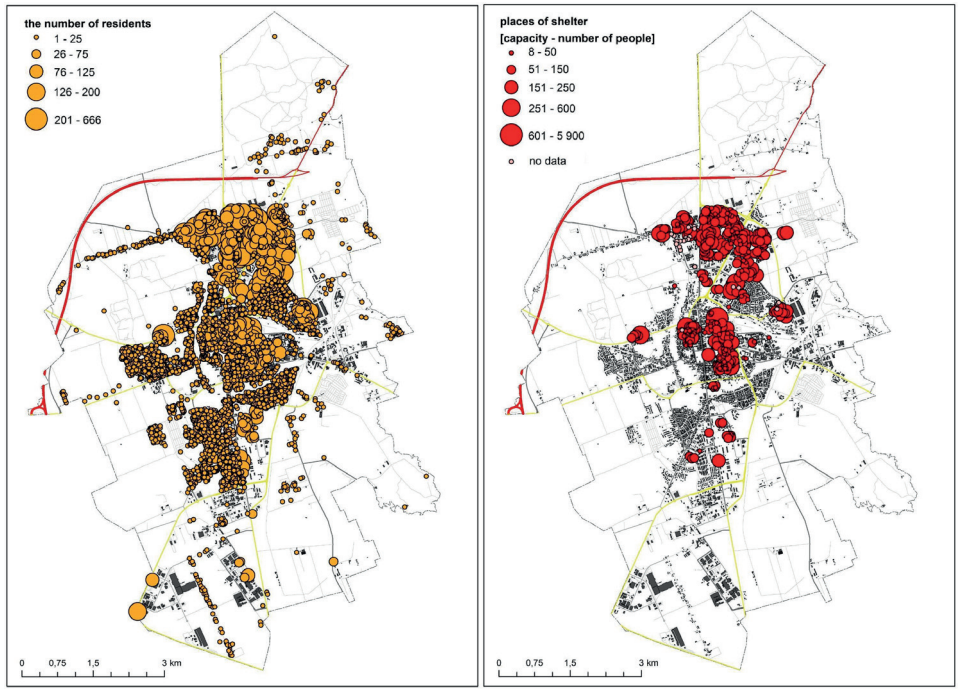

Fig. 3. Distribution of city residents (left) and location of emergency shelters (right) in Suwałki
Source: own work based on data from the Suwałki City Hall.

The existing emergency shelters can accommodate 40,612 people, predominantly in basements of residential and non-residential buildings (several garages have also been designated for this purpose). The largest number are located in

the centre and the north of Suwałki, which partially reflects the distribution of the town's population (Fig. 3). These emergency shelters are heavily dispersed (394 different locations across the town), and, on average, a single facility can accommodate 103 people. The total number of emergency shelters designated for the population is inadequate for the number of residents registered in Suwałki (Table 2).

Table 2. Basic quantitative characteristics of variables taken into account in modelling the evacuation process

Variables of modelling evacuation	Number/ capacity	Min.	Max.	Arithmetic average	Standard deviation
number of city population	66,838	1	666	13.5	35.2
number of postal addresses	4,965	-	-	-	-
existing shelter capacity	40,612	8	5,900	103.0	299.7
number of existing shelters	394	-	-	-	-
capacity of public buildings	79,690	9	157,345	637.5	1581.1
number of public buildings	125	-	-	-	-

Source: own work.

4. SOURCE MATERIALS AND RESEARCH METHODS

The basis for the model of traffic speed used in the research was the preparation of a vector model of the road network. In order to ensure the highest possible level of accuracy of the network, a road network model was built, containing the accurate mapping of the route of roads with categories ranging from national roads, through voivodship, poviat, and commune roads. Each of the sections in the database (as well as its geolocation and attributes containing the category of the road section) was assigned: road class, number of lanes, type of terrain through which it runs according to criteria used in national traffic studies (built-up, undeveloped or mixed), capacity, speed in free traffic, speed limit, frequency of junctions, density of buildings within 100 m, and the number of inhabitants within a radius of 500 m. The combination of these attributes made it possible to build the movement speed model. The basic speeds that were modelled, depending on the attributes assigned to sections, are code speed limits (determined by the relevant standards and the manner of traffic organisation by their managers) and speeds in free traffic (resulting from the technical parameters of the road). It was assumed that as the level of freedom of movement decreases, the speeds observed

on the network also drop. The aforementioned level of freedom of movement is affected by the previously mentioned attributes, i.e., the density of intersections on the road section, the density of buildings, and the number of inhabitants in their vicinity. The size of speed reduction on the road network, considering the above-mentioned parameters, was differentiated depending on the categories of roads and the types of land use they ran through (built-up, undeveloped or mixed), which is motivated by different ways of organising traffic. The aforementioned road network and traffic speed model was used, among others, in research related to transport accessibility and the load on the road network (Wiśniewski, 2021, pp. 172–183; Wiśniewski *et al.*, 2020).

For the calculation of travel times, both pedestrian and vehicular, the road and street network of Suwałki was utilised to determine the distance between research points, which were calculated according to the Manhattan metric or urban metric (the sum of absolute differences between the coordinates of points). This distance represents the path that must be traversed between points, using solely the city's street grid. The travel time was determined in accordance with the aforementioned velocity model, while pedestrian movement times were calculated assuming a constant walking speed of 4.5 km/h. Typically, the average walking speed is assumed to be about 1.2 to 1.4 m/s, corresponding to approximately 4.3 to 5.0 km/h. This speed is considered typical for adults moving in unobstructed conditions, though studies indicate that walking speed can vary depending on, among others, age and gender. Older individuals and children typically move slower (0.9 m/s) than the average adult population. In urban conditions with numerous obstacles (such as intersections or crowded sidewalks), the average speed may be lower. Therefore, despite the likely haste during an evacuation process (speed closer to maximum than to comfortable), a decision was made to adopt an intermediate value between threshold values.

In order to determine the transport accessibility of the population at risk to the evacuation sites, vehicular travel or walking times between the designated start and end points were measured in accordance with the speed model. The next stage of the study was to determine the sections connecting the starting points and destinations adopted for the analysis – individual elements of the truss. Spatial adjustment of the distribution of emergency shelters was determined by market areas. To ascertain the spatial differentiation of accessibility to evacuation sites, the Enhanced Two-Step Floating Catchment Area Method (E2SFCA) was used in a modified version to capture the essence of the study as accurately as possible.

In the variant examining the spatial fit of evacuation sites to the population distribution, the focus was on the links between the population distribution and the location of these specific facilities. In terms of availability, the study focuses on determining the level at which the supply of places available in such facilities intended for the evacuated population corresponds to its theoretical

demand. By considering both dimensions we were able to develop the most comprehensive analysis of accessibility. This solution also makes it possible to avoid interpretation errors accompanying analyses based on the capacity per inhabitant of a given area. These are studies without a spatial character, e.g., due to not considering the border effect or the inability to determine the relationship between the distribution of facilities and the distribution of population. Based on the classic version of the two-stage floating catchment method (2SFCA), an enhanced version (E2SFCA) was introduced. This version introduces weights to the original method that enable one to distinguish individual time ranges of access to facilities. Thus, this model is based on a more rational assumption of the demand for space in such facilities. This weight is then used to calculate the space needs of individual populations, eliminating classically occurring overestimations.

The 2SFCA approach was used due to its relative simplicity and intuitiveness, which facilitates its understanding and application. Given the limitations on access to sensitive data (e.g., personal data) concerning the evacuation process, it is beneficial that it does not require complex input data. Moreover, considering the applied nature of the study, the method does not require advanced analytical tools, making it accessible to a wide range of users, including planners and decision-makers. Flexibility is also an important factor. The method allows for adjustments depending on the specifics of the area studied and the data available. It can be used to assess the availability of various types of services, including those as specialised as crisis management. It enables balancing supply and demand in the availability analysis, providing a more balanced view of the situation than those methods that focus solely on one of these aspects. 2SFCA facilitates the modelling of future service availability scenarios, such as the opening of new facilities (e.g., emergency shelters) or changes in population distribution. This allows planners and decision-makers to better assess the potential impact of planned interventions and optimise resource allocation.

The first part of the method is based on determining the area of influence of each object, assuming a borderline value for the travel time (in this study, maximum travel times of 8 and 15 minutes were assumed in the case of the evacuee organising their own transport). For each of the objects, the isochrone of the theoretical travel time are plotted. Then, for the designated zone D, all objects are found and weight assigned to each according to the exponential function. The fundamental component determining the results of the accessibility model is the space resistance function used. Originally, the E2SFCA method proposed by Luo and Qi (2009) used the Gaussian distribution, but in this study it was decided to use the exponential function, the most common in empirical research (Wiśniewski, 2021).

Commuting to a place of refuge or accommodation facility for evacuees was classified as a very short journey. For each of the facilities, an individual TRj in-

dicator was calculated, which is its weight per the summed number of residents (potential evacuees) living in buildings located in the area designated by a given isochrone:

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \in D\}} P_k W_r}$$

where:
S_j – weight (capacity) of the object j;
W_r – weight consistent with the exponential function for the zone of potential service for people evacuating,
P_k – size of the population k of the address point i within the scope of the study,
d_{kj} – travel time between object j and address point i with population k.

In the second part of the analysis, attention is focused on the address points of residence of potential evacuees. For each of them, the area is determined, as in the first stage of the analysis, using the adopted limit values of the time of travel to the objects. Then, for each building, the accessibility index is calculated, which is the sum of the products of the R_j values obtained for individual objects and weights W_r in the area of the individual building area and:

$$A_i^F = \sum_{j \in \{d_{ij} \in D\}} R_j W_r$$

The number of analysis variants included in the study is determined by four variables, each of which has a dichotomous nature (Fig. 4.). The first element is the maximum duration of the journey to the facility intended for receiving evacuees, which has two ranges: 0–8 minutes and 8–15 minutes. The second element is the type of refuge. Cases were considered in which the population evacuated to emergency shelters and public buildings. The third variable is the form of evacuation, scenarios of self-evacuation and organised evacuation for people unable to escape independently were included.

In the section of the article focusing on the results, the outcomes of the conducted optimisations of emergency shelter locations, considering the variables mentioned above and in Fig. 4, were presented. These were captured both in cartographic form (limited due to the scope of possibilities considered) and synthetically in the form of a summary table, which includes indicators defining, among other things, time efficiency and effectiveness (the number of residents covered). Maps presented the final results of spatial matching of emergency shelters to residential areas. They did not show the individual phases of the 2SFCA implementation, as this would double the already rich number of figures (supplied separately for the differentiation of demand and supply).

Fig. 4. Variables considered in the process of modelling the optimal arrangement of facilities intended for evacuation

Source: own work.

Considering the research method applied and the variables included in the analysis variation, the optimisation of the location of emergency shelters or facilities that could serve this role was conducted using the location-allocation tool (available in the ArcMap package). The input data for this tool includes service-providing facilities (here, safety during an armed conflict or the threat thereof) and demand points (residences) that consume this service. The goal was to find the facilities that most effectively supply the demand points, considering the competition in terms of demand (for shelter) and supply (for residents). The tool solves this problem by analysing different ways of assigning address points to various facilities. The solution is a scenario in which the greatest demand is allocated to facilities and the costs (time) of travel overall are minimised. Emergency shelters are located (or chosen from actual locations) in such a way that the entire or greatest demand for their space (available places) can be met without exceeding the capacity of any facility. Maximising capacity coverage functions like a P-Median problem but with an additional efficiency constraint. The sum of the entire weighted travel time (the weighting being the demand allocated to a facility multiplied by the time to reach it) between address points and emergency shelters is minimised. For each study variant, default cutoff point values of 8 and 15 minutes of travel time were assigned. If the total demand for emergency shelter spaces by the population that could reach it was greater than its capacity, only those address points were allocated (according to the results of applying 2SFCA) that maximise the total demand while simultaneously minimising the total weighted travel.

In order to determine the characteristics of the evacuation process for residents of Suwałki a survey was conducted. It was performed using the CATI technique on a sample of 400 residents (from 1 March to 12 April 2023), following a prior pilot study. It consisted of three parts: respondents' particulars, questions about awareness of the risk, and knowledge about correct behaviour in case of war. Women aged 18 and over and men aged 60 and over were eligible to participate in the study. Residency, gender, and age were the only criteria for entering the sample, therefore, other characteristics were distributed randomly.

In addition, the person responsible for emergency management in Suwałki was contacted. This was to gather information about the city's preparedness in terms of

alerting civilians and conducting the evacuation process in the event of an armed conflict. The relevant person had to fill out a survey questionnaire previously designed by the research team, which was sent to them by email. Thanks to the questionnaire, documents at different levels (local, regional, and national) that deal with emergency management were identified. Information was also obtained on the dispersion of knowledge and evacuation training provided to both residents and emergency management personnel alike, as well as the measures the city has taken to increase the safety of residents should an armed conflict on their territory occur. The questionnaire also attempted to ascertain what kind of support was needed in terms of increasing the safety of residents.

Thus, in the following part of the article, elements considered in the research procedure are presented in the following order: a characterisation of the spatial mobility of residents in the context of evacuation necessities; a description of the city's development and its immediate surroundings, with special attention on the distribution of emergency shelters, residential areas, and the transportation network; and the results of optimising the spatial allocation of emergency shelters in line with the population distribution.

The limitations of the study presented may pertain to:

– Weaknesses in the applied method of accessibility analysis. In E2SFCA, weighting functions are utilised to modulate the impact of distance on accessibility. The choice of the appropriate weighting function and its parameters is crucial for the outcomes, but it can also be a source of subjectivity and uncertainty. Despite improvements, E2SFCA still assumes a degree of uniformity in the interaction space. Although the method accounts for distance weighting, it may not accurately reflect real accessibility patterns, especially in diverse geographical and social contexts.

– Weaknesses in the applied questionnaire study. War is an exceptionally sensitive and emotive subject, which may affect the willingness to participate in the study or the honesty of the responses. Respondents might avoid answering difficult questions or might be reluctant to express their true opinions for fear of repercussions. War is a period of significant changes and uncertainties, meaning that the attitudes and behaviour of the population can change rapidly. The results of a study conducted at one point in time can quickly become outdated due to evolving events.

– Weaknesses stemming from the utilised source databases. Official data is often published with a delay relative to the moment of its collection. This means that it may not reflect the current state of population distribution, especially in dynamically changing urban areas. Official population distribution data often does not account for the mobility patterns of residents, such as commuting to work or seasonal migrations, which is crucial for a full understanding of urban dynamics.

– Weaknesses resulting from the lack of data on the daily mobility of residents. Unfamiliarity with the movement patterns of pedestrians, cyclists or drivers can lead to inappropriate safety infrastructure design, increasing the risk of accidents and collisions.

5. RESULTS AND DISCUSSION

To date, no such sophisticated analysis of the population evacuation process has been conducted for Suwałki. Our study revealed that the vast majority of respondents (over 70%) would self-evacuate if military operations occurred in their town. Most people (86.3%) would choose to self-evacuate by car (Fig. 5). 85.75% of the respondents declared that everyone in their household would be able to self-evacuate. In those households that required assistance, 11.25% said that one person would require to be evacuated by emergency services, in approximately 3% this would be two people. Similar results for self-evacuation in the event of a natural disaster (a flood) were presented by Borowska-Stefańska *et al.* (2023) and Shenhar *et al.* (2008).

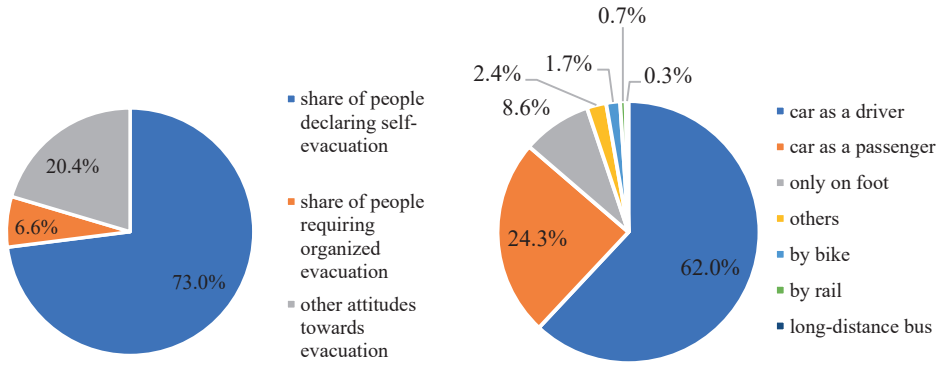

Fig. 5. Declared form of participation in the evacuation process and modal division during its duration

Source: own work.

The survey showed that only 24.5% of the respondents were aware that there were emergency shelters in Suwałki. The rest were either unaware of this fact (47%) or believed that there were none (28.5%). Therefore, most respondents would evacuate to places designated by emergency services (27.2%). Importantly, some respondents stated that they would choose to evacuate to locations outside the city of Suwałki (e.g., to another town) or even abroad (12.2%) (Fig. 6). A telling response was that 389 of the 400 respondents declared that they were unfamiliar with evacuation guidelines in the event of war. The lack of knowledge about evacuation rules in the case of war has also been confirmed by studies conducted in other countries (Borowska-Stefańska *et al.*, 2024). As Shakibamanesh (2015) has indicated, people should know where to evacuate to and without this knowledge the process cannot be properly managed.

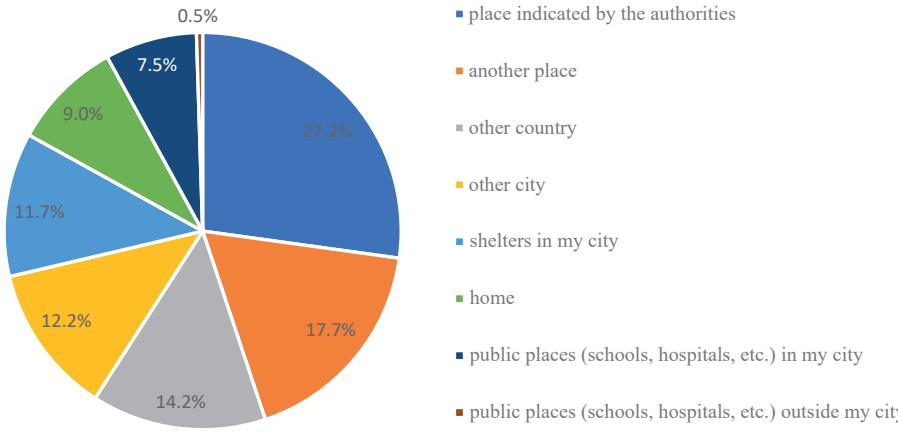

Fig. 6. Declared evacuation destination
Source: own work.

Emergency shelter management is a key part of emergency logistics and disaster operations (Alisan *et al*., 2020a, 2020b). As shown in Fig. 7, the vast majority of residents of the city of Suwałki can reach existing emergency shelters or suitable public buildings within 15 minutes. As regards accessibility on foot alone, both emergency shelters and public buildings (Table 3) can be reached within 15 minutes by 94.1% of all residents. Time is crucial when organising evacuation and rescue operations. If the first emergency services arrive at the areas in question within 15 minutes, it is then possible to provide effective assistance to those in need (Drzymała *et al.*, 2014).

The capacity of emergency shelters is, however, insufficient, i.e., on average there are 1.5 inhabitants for every seat in a shelter which can be reached within 8–15 minutes, while the figure for suitable public buildings that could be transformed into additional shelters amounts to 0.8 (Table 3). A number of studies have most commonly used the shortest Euclidean distance, cost distance and road distance method to assess shelter accessibility (Jiang *et al*., 2018). However, while distance analysis alone indicates high emergency shelter accessibility, allocating people at risk to emergency shelter sites using this method alone leads to overcrowding (Su *et al.*, 2022).

Based on the survey, it was assumed that 6.6% of the population of the city of Suwałki would require evacuation by the emergency services. A simulation was conducted to see how many ambulances would be required and how long the process would take if assistance was provided to all those in need concurrently. The study revealed that if it was to be provided solely by the emergency services operating in the city of Suwałki, they would need to have at least 10 vehicles at their disposal.

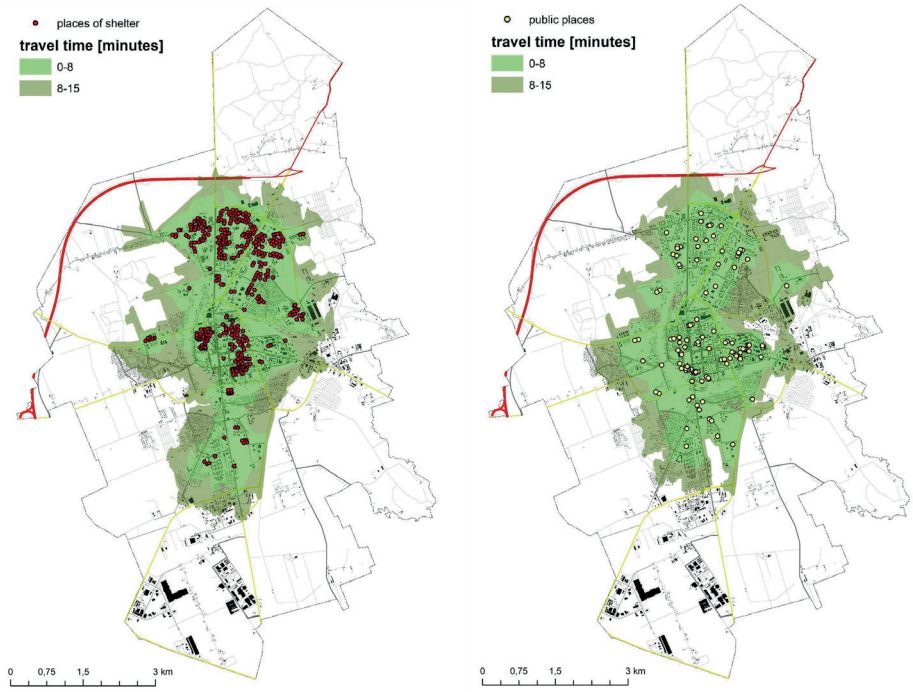

Fig. 7. Spatial differentiation of pedestrian accessibility to places of refuge (left) and public buildings (right)

Source: own work.

Table 3. Current occupancy and coverage of the demand for emergency shelter places

		0–8		8–15		Out of protection		On average per emergency shelter/public building		On average per place in an emergency shelter/public building	
		number	share	number	share	number	share	0–8	8–15	0–8	8–15
to public building	postal addresses	2673	53.8%	1670	33.6%	622	12.5%	21.4	34.7	0.0	0.1
	population	50465	75.5%	12420	18.6%	3953	5.9%	403.7	503.1	0.6	0.8
to existing emergency shelters	postal addresses	2862	57.6%	1481	29.8%	622	12.5%	7.3	11.0	0.1	0.1
	population	57027	85.3%	5881	8.8%	3930	5.9%	144.7	159.7	1.4	1.5

Source: own work.

Importantly, to smoothly evacuate all residents in need, each vehicle would have to travel for one hour and each would have to take a different route to avoid creating bottlenecks. As the results of a study by Fei *et al.* (2023) show, while it is important to have an even distribution of emergency services or medical facilities, it is generally important to remember that they are limited in number and can quickly become overloaded without proper management.

Based on the results of the questionnaire survey, a traffic simulation was also conducted to determine the impact of self-evacuation, either on foot or by car, on the urban transport system, for evacuees fleeing outside the city limits. It was possible to identify which roads would require additional measures during evacuation to prevent congestion and to ensure that emergency services could operate along them (by diverting traffic along alternative routes). Figure 8 shows which areas of the city would experience the greatest traffic disruption if not properly managed.

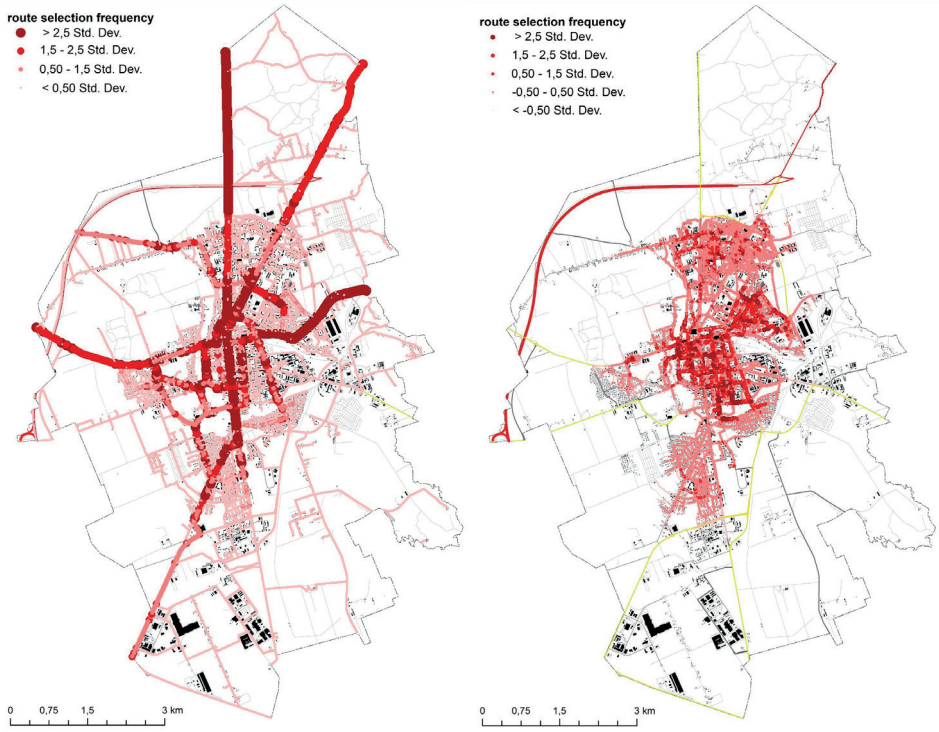

Fig. 8. Spatial differentiation of the load on road junctions resulting from: vehicular traffic of people evacuating outside the city and the activities of emergency services (left) and pedestrian traffic of people moving to emergency shelters in the city of Suwałki (right)

Source: own work.

Research by Borowska-Stefańska *et al.* (2023) revealed that self-evacuation in response to an emergency impacts both the spatial distribution of the load on the road network and travel speeds, although this is also determined to a certain extent by the capacity of the local transport system. It is important that people are kept informed of the available evacuation routes (including evacuation on foot), which would need to be adapted to the prevailing traffic conditions. Otherwise, evacuees will only use "familiar" routes, which may prolong the evacuation process. Therefore, providing up-to-date, reliable and clearly articulated information to road network users would improve the performance of the entire transport system.

Determining the optimal locations of facilities with the amount of assistance elements needed remains an important aspect, while others have focused on determining the optimal locations of facilities with the amount of assistance elements needed (e.g., Kocatepe *et. al.*, 2018). Our research shows the optimum distribution of (existing) emergency shelters that can be reached within 8 or 15 minutes, together with information on the number of postal addresses (properties) they should serve (Fig. 10). This has been determined based on the following: the locations of buildings, the results of the survey, and the population's declaration to self-evacuate (including evacuation to emergency shelters). This reflects the actual situation in the town while excluding those emergency shelters that would take over 15 minutes to reach (i.e., location considered unsuitable). It must be noted that the highest density of emergency shelters is in the central part of the town, as these would possibly have to serve the largest number of postal addresses in the face of evacuation under war footing. It is evident that these places correspond well with the distribution of single and multi-family housing in the north and south of the town. This, in turn, means that shelters in these areas would probably have to serve considerably fewer postal addresses.

It displays the distribution of the lowest required number of emergency shelters for residents of the city of Suwałki (among facilities that are currently designated as emergency shelters) reachable within 8 and 15 minutes, where their actual capacity (not just postal addresses) was considered. Figure 10, however, is extended to include those residents who declared that they would self-evacuate to emergency shelters, or to other places designated by the authorities. These analyses reveal that, as regards the capacity of the places of refuge and their accessibility, emergency shelters located in the very centre of the town are the most important for the protection of the civilian population (excluding those that would serve individual residents only). However, there is an excess of emergency shelters in the centre when the analyses are extended to include further scenarios (self-evacuation to emergency shelters and places designated by emergency services). Then the buildings designated as emergency shelters located to the north and south of the town centre would face greater occupancy.

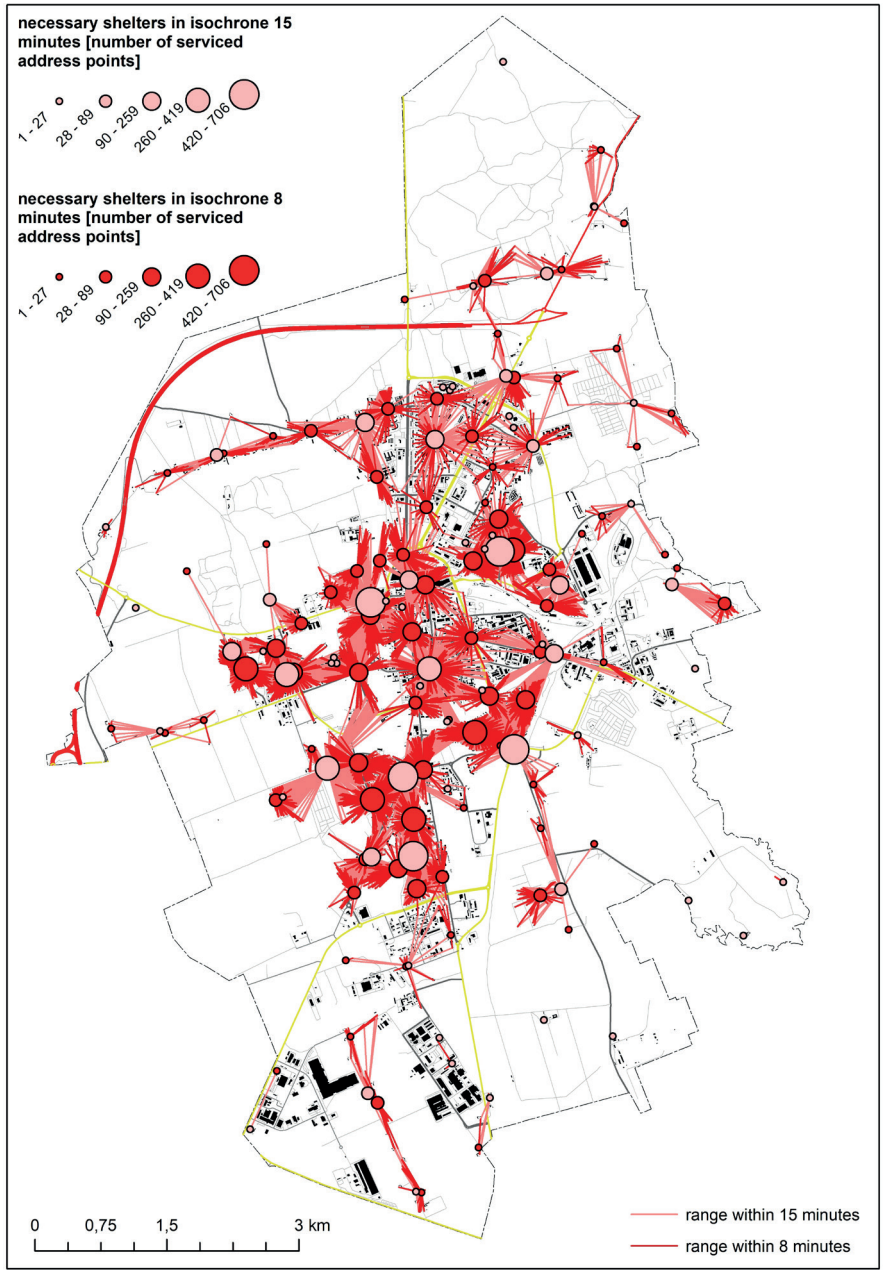

Fig. 9. Spatial arrangement of the required number of emergency shelters (from the set of those currently existing) enabling evacuation in 8 or 15 minutes, together with the number of serviced address points

Source: own work.

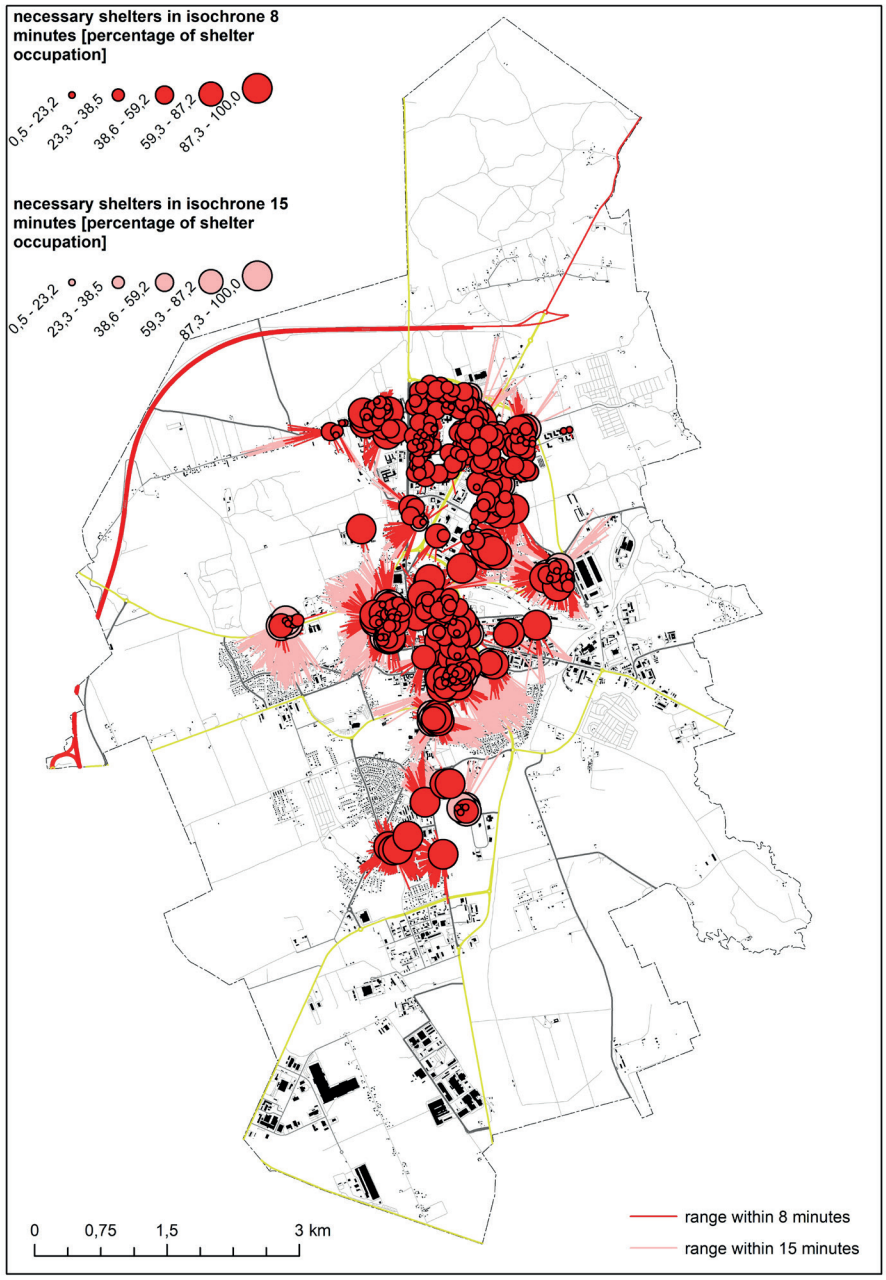

Fig. 10. Spatial arrangement of the required number of emergency shelters (from the set of those currently existing) enabling evacuation in 8 or 15 minutes, along with their occupancy level – extended to include persons carrying out orders from the emergency services

Source: own work.

By dint of having the highest population density, the town centre is the most critical area for the emergency services (firefighters, paramedics, etc.) when it comes to disaster management (Coutinho-Rodrigues *et al.*, 2012). Identifying the most critical sites, whose loss through destruction would be most undesirable, also remains one of the problems associated with emergency shelter management in the planning process (Galindo and Batta, 2013).

Among all existing facilities that either are emergency shelters now or could be transformed into them, locations were selected that residents could reach within the designated time (for each facility the number of people to be accommodated is indicated). 100 locations were proposed that would be reachable by all residents within 8 minutes, and 49 locations within 15 minutes (Table 4). While both variants are workable, it is certainly easier to manage a smaller number of facilities and to protect these buildings in the event of a war. A similar study indicating a proposal for alternative emergency shelter locations in case of war was conducted by Alisan *et al.* (2020b). Figure 11 shows the analyses extended to include those residents who not only declared they would self-evacuate to emergency shelters, but also to additional sites designated by the authorities. However, due to the low-density housing outside its central area, one could state that emergency shelters are basically indispensable throughout these areas. For the extended scenario when there is the need to serve more residents, the number of emergency shelters reachable within 8 and 15 minutes would be identical as in the first variant (Table 4).

Evacuating people to a building that is not classified as a dedicated place of refuge is not a conventional solution. However, with proper identification of the risk and prompt warning, this type of building for evacuation can be effective (Cisek *et al.*, 2018). Figures 12 shows suitable public buildings that have not been designated as emergency shelters in the official evacuation documentation for the city of Suwałki, but could be assigned as temporary emergency shelters. It shows the existing public buildings that should be designated by the authorities as emergency shelters and considers the capacity of these facilities; the residents' expected behaviour and the distribution of people who declared they would self-evacuate to emergency shelters should it be necessary. Residents of the city of Suwałki in need of evacuation should be directed by the emergency services to the designated public buildings. This evacuation would mostly be supervised by emergency response units from outside the town. The minimum number of public buildings reachable by residents within 8 minutes was determined, and it equals 89 (Table 4). As Shakibamanesh (2015) has indicated, emergency shelters should be in public building that also fulfil alternative functions (in times of peace) and the time to reach them should be as short as possible.

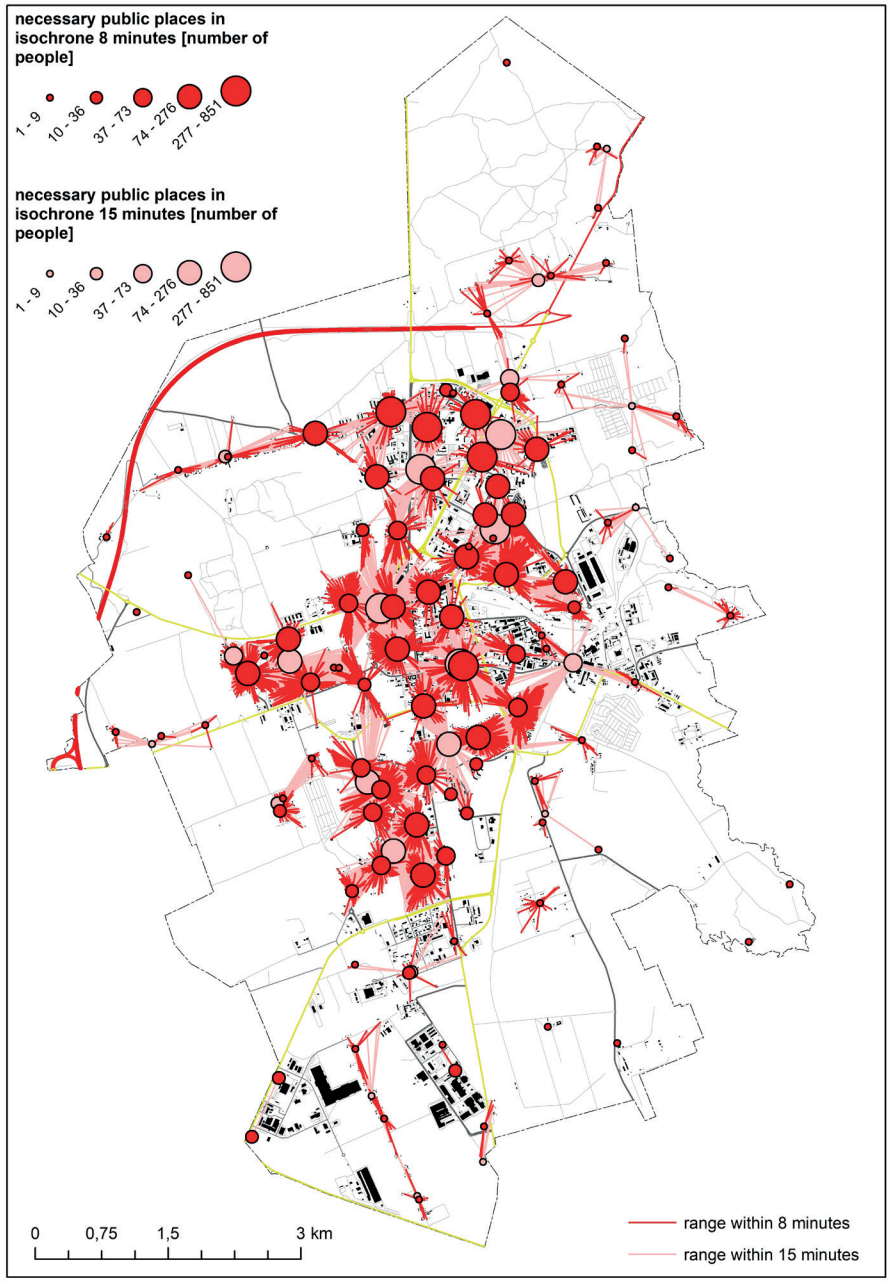

Fig. 11. Spatial arrangement of the required number of new emergency shelters enabling evacuation within 8 or 15 minutes, together with the number of people served – extended to include people following the instructions of the emergency services

Source: own work.

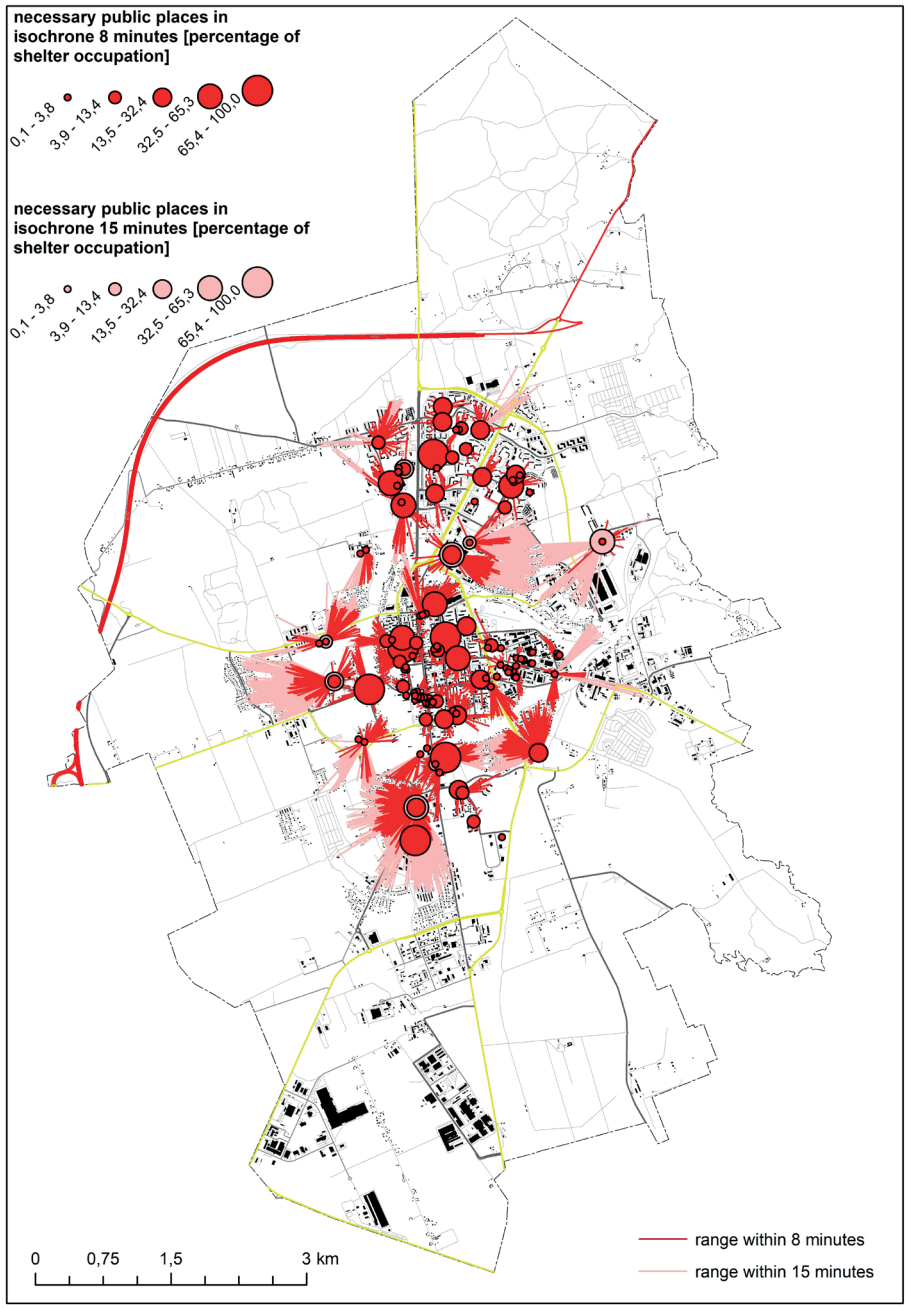

Fig. 12. Spatial arrangement of the required number of public building serving as places of refuge enabling evacuation within 8 or 15 minutes, together with the level of their occupancy

Source: own work.

Table 4. Quantitative characterisation of the effectiveness of the proposed locations of emergency shelters

Emergency shelters	Evacuation time [minutes]	Number	Capacity [number of seats]	Share of the maximum capacity [%]	Number of supported postal address	Share of serviced postal address [%]	Number of people served	Share of the number of people served [%]	Cumulative evacuation time [minutes]
new locations of places of refuge [objective: serving the population]	8	100	-	-	4,965	100.0	5,718	100.0	299
	15	49	-	-	4,965	100.0	5,718	100.0	566
new locations of places of refuge [goal: handling postal address]	8	121	-	-	5,840	100.0	-	-	332
	15	64	-	-	5,840	100.0	-	-	599
Existing locations of places of refuge [objective: serving the population]	8	349	38,956	96.0	2,761	55.6	4,811	84.1	174
	15	349	39,092	96.3	4,217	84.9	5,322	93.1	466
Existing locations of places of refuge [objective: serving an extended population group]	8	352	39,555	97.4	2,290	46.1	15,394	81.1	136
	15	354	39,812	98.1	3,348	67.4	16,692	87.9	336
New locations of places of refuge [objective: serving an extended population group]	8	100	-	-	5,840	100.0	18,981	100.0	299
	15	49	-	-	5,840	100.0	18981	100.0	566
Public buildings [objective: serving self-evacuation]	8	86	48,028	60.3	2,282	46.0	2,173	59.5	164
	15	86	48,028	60.3	3,801	76.6	2,764	75.7	441
public buildings [objective: handling organised evacuation]	8	89	49,140	61.7	4,965	100.0	4,411	100.0	86

Source: own work.

6. CONCLUSIONS

Evacuation is a strategy commonly employed as a response to emergencies. Unfortunately, its planning is an extremely complex process, involving many aspects of emergency management, land use, and expected human behaviour in an emergency. It is, therefore, essential to take all measures possible to support and optimise this process, including setting evacuation routes, designating emergency shelters, and properly managing the role of the emergency services. The aim of this article is to assess the spatial matching of existing emergency shelters (supply) to the distribution of residents in Suwałki (demand), considering their declared transport behaviour in the process of evacuation in case of war. The rationale behind this research was to develop and test different scenarios for modelling the location of emergency shelters, considering the distribution of the population and destination buildings, as well as the declared behaviour of residents in the event of a war. The results may serve as a set of recommendations for those in charge of crisis management in the city of Suwałki, its residents, and the emergency services involved in the process of evacuation. Although crisis management plans already exist for the city of Suwałki, they are neither public nor do they contain detailed guidelines. Additionally, the residents do not receive any training on how to act in the event of a war. As a result of the population being unaware of the presence and location of emergency shelters in the city of Suwałki, they would be unsure to where to evacuate. Introducing specific guidelines for emergency services, residents and municipal authorities into crisis management plans could reduce the number of casualties during a war. Moreover, the current capacity of emergency shelters is not sufficient for the number and distribution of inhabitants of Suwałki, therefore, the most practical recommendation in this respect is to indicate to the authorities the optimal number (to improve the evacuation process) and location of emergency shelters. The analyses also revealed how important self-evacuation is, proposing that residents of the city of Suwałki should walk to emergency shelters located within the town limits that are easily reachable on foot within 8 or 15 minutes (as long as the evacuees are properly guided by emergency services and know the specific location of these facilities). Given the size of the city of Suwałki and its layout, residents are advised against using a car for intra-town evacuation. The analyses also revealed that the designated emergency shelters are overly dispersed, making management difficult for emergency services. Their number should, therefore, be reduced in both the centre and also in the northern and southern parts (where they would only serve a limited number of residents). When planning urban land use, dispersed development should be prohibited (here, for the sake of evacuation and its smooth management). Training for residents in wartime evacuation and preparedness should focus on those who live in less densely populated areas and, therefore, may be forced to self-evacuate.

In addition, this training should especially target both the elderly and those who would need to be evacuated by emergency services.

The study clearly underlines that in a war scenario, Suwałki would benefit from external assistance, particularly from the fire brigade, underscoring the urgency for coordinated efforts among these emergency services, especially for rural areas, which would be the primary source of such assistance. In this context, it is particularly unfavourable that at the regional level there are no plans for the evacuation process, an oversight, as this research proves.

This research also underscores the immediacy of implementing these recommendations to fortify the city's crisis response mechanism. Effective spatial planning and targeted resident training could be pivotal in reducing casualties and ensuring swift evacuation, ultimately forging a resilient Suwałki capable of responding to war. This conclusion, therefore, not only offers critical insights for authorities and emergency services but also empowers residents, enabling them to act decisively and confidently in the face of future crises.

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BOOK REVIEWS

Vladimír SLAVÍK, *Cross-border cooperation and foreign partnership cooperation (Cezhraničná spolupráca a zahraničná partnerská spolupráca)*, Bratislava: Comenius University, 2023, 226 pages

The reviewed work is a result of the author's long-term activity in the field at the level of basic research, didactic interpretation, as well as application in public administration. Although I am convinced that the publication could have come to existence already long ago, I have to admit that its longer "maturation period" had a positive effect on the final output. In my opinion, my colleague V. Slavík successfully managed to interconnect closely related subjects, namely border research chiefly from a geographical perspective and the study of the decision-making sphere as an important phenomenon for regional development.

At the same time, a similar pattern or principle of hierarchical observation has been applied within both levels, starting from theoretical (general) features through global, continental (European, Central European or "neighbourhood"), national, regional up to local dimensions. I agree with the author that the issue concerning cross-border and partnership (meant always foreign) cooperation has only recently been included in professional texts dedicated to regional development and regional politics. Therefore, I am glad that – in a way – the textbook fills in these blank spaces.

The presented comparison of development and situation at different scale levels then supports a plastic (complex) perception of the relevant issue, which is so close to geography as a scientific discipline. As a "foreign" reviewer, I am naturally pleased by the attention paid either to the Czech Republic as a close

neighbour and nation, or indirectly further west to Germany as a driving force of European integration, including cross-border and partnership cooperation. I am convinced that specifically cross-border and partnership activities are a tangible manifestation of Europeanisation, which should not only managed, but also promoted.

In the process of text creation, the author used countless titles of diverse nature, language, extent and provenance, as well as a number of accompanying tabular, graphical, and cartographic elements. The variety of the textbook's elements adds to its attractiveness: seen from works of legal character up to selected findings obtained, e.g., from the research of one locality. This "inventory" alone would be praiseworthy and, to a certain extent, it builds on similar works from the beginning of the millennium. It is surprising how Slavík (as the sole author) managed to interconnect these "sources" and present them synergistically. I do not know any similar publication, at least in the Central European context. Although the focus on the Slovak situation is evident, examples from "elsewhere" form an integral part of this book.

The chosen structure of the book is natural, its individual parts (Chapters 1 to 6 with different extents) follow each other logically. I have already stressed above the interconnection of two topics: the central issue and the description of external environments (framework conditions) for cross-border and/or partnership cooperation.

As the work is primarily a textbook, I evaluate the didactic concept, too, having no major comments. The text itself is dense, but retains the required legibility. The illustrative or accompanying material is relatively rich (31 tables, 23 graphs, 2 diagrams, 23 maps, and 73 images), which certainly contributes to the attractiveness of the publication. This component includes both well-known elements and – what I appreciate – completely new, original or adopted, elements that are fully left in an original shape. Professional terminology applied corresponds to relevant standards.

Personally, I do not quite agree with the author's statement about the novelty of interest in the borderland. Rather, I am inclined to strengthening interest in research and increasing its significance, particularly in connection with principal political milestones. In modern history it was, e.g., the split of Czechoslovakia in 1992/1993, the accession of the two successor states to the European Union in 2004, the incorporation of Slovakia (and the Czech Republic) into the Schengen Area in 2011, etc. Likewise, it is untrue that no cross-border cooperation occurred before 1989, at least between "friendly" countries of the Eastern Bloc, for example, in the Czechoslovak-Polish border area.

I am convinced – thanks to language proximity – of the potential use of this publication not only at Czech university workplaces, but also within public administration. Regional development requires professional solutions and the reviewed work provides enough study material for diverse target groups. In my

view, it is exactly a considerable overlap from the academic environment to the decision-making sphere that can be deemed positive; after all, the author has cultivated and promoted this approach throughout his career.

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FROM EXPORT OBSESSION TO ENERGY TRANSITION: HOT TOPICS IN GERMAN ECONOMIC GEOGRAPHY

With a review of:

Jan-Otmar HESSE, *Exportweltmeister. Geschichte einer deutschen Obsession*, Suhrkamp Verlag, Berlin 2023, 447 pages, Elmar KULKE (ed.), *Wirtschaftsgeographie Deutschlands* (third edition), Springer, Berlin 2023, 400 pages, and Ingo LIEFNER and Sebastian LOSACKER, *Nachhaltige Wirtschaftsgeographie*, Brill Schöningh, Paderborn 2023, 259 pages

1. INTRODUCTION

German scientists have made a major contribution to the development of economic geography as an academic discipline. Traditionally, Germany has had wide regional and local disparities, which may explain why economists like Von Thünen, Weber, and Christaller were early to explore the spatial dimension of production and consumption. It was also a German textbook that three decades ago sparked my interest in economic geography: Ludwig Schätzl's *Wirtschaftsgeographie* (three volumes, on theory, empirics, and policy). The first edition of this trilogy appeared in 1978 and has been updated numerous times since.

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Economic geography, which Schätzl defined as 'the science of the spatial order and the spatial organisation of the economy' (*translation GJH*) is a broad field of study. Not only does it focus on different spatial scales, but it also stresses historical aspects. After all, location-specific differences often have their basis in an area's past. We see this breadth reflected in the books we review here: a treatise on Germany as an exporting country, a textbook on the regional and sectoral side of the German economy, and a plea for a more forward-looking and sustainable interpretation of economic geography. Obviously, in terms of theme and perspective, the books differ from each other. But together, I think, they give a good impression of what is unfolding in German economic geography at the moment.

2. WORLD EXPORT CHAMPION

Since 2009, China has been the world's largest exporter of goods. But in some years prior, for example between 1986 and 1988 and between 2003 and 2008, Germany was the global export champion. Still, German products are in high demand worldwide – the label 'Made in Germany' stands for quality. How did Germany, a country poor in raw materials, manage to become such a successful exporting nation? This interesting question is posed by professor Jan-Otmar Hesse, economic historian at the University of Bayreuth, in his book *Exportweltmeister. Geschichte einer deutschen Obsession* (World Export Champion. History of a German Obsession'). Apart from being interesting, the question is relevant because exports are vital for the German economy: over 40 percent of Germany's GDP in 2022 was earned in the export sector, while a quarter of the country's jobs depends on it.

In search of the background to this success story, Hesse starts with an overview on trade theory and presents detailed statistics on Germany's role in the global economy since the 19th century. The following chapters are chronological and cover the time span between 1890 and the present. In that period, Hesse sees 1952 as an important year, because that was when Germany actually managed to export more than it imported – an ambition (Hesse calls it 'an obsession') that the country has had ever since Reichskanzler Leo Graf von Caprivi in 1890 proclaimed that without a strong export economy, the country 'could not survive.' In the rise of Germany as an export champion, two types of actors have played a crucial role, according to Hesse: companies on the one hand and politicians, on the other.

To begin with, Hesse points to Germany's large industrial base with numerous manufacturing companies. In most of these firms, innovation, service and adaptability are key values. Take Bosch's invention of magnet ignition at the end of the 19th century or the good value for money of the VW Beetle in the time of the *Wirtschaftswunder*. Traditionally, German companies are distinguishable for their

delivery reliability and high service levels. Over the decades, German firms have also moved parts of production abroad at the right time, which allowed them to reduce costs. Although Hesse goes into detail about the strength of the German manufacturing industry, I am surprised that he pays so little attention to the 'hidden champions,' i.e., enterprises that often have firm local roots and whose names are quite unknown, but that, thanks to their strong specialisation, are world market leaders (Simon, 2009). Think of Symrise, based in Holzminden (Lower Saxony), supplying fragrances and flavourings for over 30,000 products worldwide, which has an export share of 90%.

Next, extensive support by the government made a significant contribution to the rise of Germany as an export superpower. As early as 1926, for example, the Hermes-Bürgschaft was created, in which the state, together with private insurance companies, dealt with the risks of defaults in export business. After the Second World War, the state also stimulated exports with tax breaks and subsidies for foreign investment. In addition, Germany established a unique institutional system around export promotion: no country has such a well-developed infrastructure in this area, ranging from German trade fairs and information points to chambers of commerce and diplomatic representations abroad. And until 1973, when the Bretton Woods fixed exchange rate system collapsed, German politicians made every effort to keep the value of the D-Mark stable and avoid the currency's revaluation.

Hesse's book is well written and, thanks to the lack of jargon, understandable also for non-specialist readers. Simultaneously, it is extremely well documented and scientifically sound – it has a 75-page notes section and a 35-page bibliography! That the author has largely omitted the German export of services, is surprising, but not a major issue. However, even though the book is primarily a treatise on economic history, it is a pity that Hesse devotes so little attention to recent developments around Germany as an export nation, simply because there is so much to say about it. What do the COVID-19 crisis and subsequent calls for de-globalisation and de-risking mean for the country's export orientation? And is the strong German automotive industry managing to remain globally competitive at a time when Chinese electric vehicles are flooding the market? Yet this criticism may also be taken as a compliment because like all good books, Hesse's work offers food for thought and raises new questions.

3. THE MESO PERSPECTIVE

The editor of the attractively designed and richly illustrated textbook *Wirtschaftsgeographie Deutschlands* (Economy Geography of Germany) is Elmar Kulke, professor at the Humbolt University in Berlin. Due to recent developments in

the world economy the edited volume is experiencing its third printing and has been completely revised. As in 1998, when the first edition appeared, Kulke now found academic economic geographers from all over the country willing to write a chapter on a sub-aspect of German economic geography. They do so from the meso perspective, that is, a sectoral and/or regional view of the economy. After the preface, the book begins with four general chapters dealing successively with changes in the sectoral structure, regional differences, regional labour markets, and the nation's place in the global economy. This is followed by eleven chapters that provide an overview of the various industries in the German economy and their spatial dimensions.

The book discusses the branches underlying the national economy according to the classic division into primary, secondary, and tertiary activities (agriculture, manufacturing, and services). But unlike many other textbooks, this one deals with these activities in detail. For example, in addition to a chapter on agriculture, there are special chapters on mining/resource extraction and on energy supply. And when dealing with manufacturing, the automotive and high-tech industries, which are so important for Germany, are specifically discussed. The book also gives the service sector its due attention: besides retail, logistics, creative industries, and tourism, Germany's housing market as well as its banking and finance system receive separate attention. Altogether, the eleven branch overviews provide a detailed and up-to-date picture of the branches and their spatial embeddedness in the German economy.

The nice thing for the reader is that in each chapter theory is linked to practice. General insights about the sector in question are immediately illustrated by statistical material. Moreover, maps, figures and photographs give a vivid picture of the situation in Germany. There are also case studies that enliven the topics covered. For example, in the chapter on agriculture, you will learn more about the agricultural cluster in Oldenburger Münsterland, while the chapter on mining/resource extraction discusses the glass and porcelain industry. The Ruhr region and the German film industry are also given ample attention. The treatment of the regional innovation systems of Munich and Dresden is interesting as well. Clearly, despite the fall of the Berlin Wall, the situation between western and eastern Germany remains uneven, an observation recurring throughout the book.

In summary, the book is a rich source of insights on the meso level of the German economy. As editor, Kulke succeeded in challenging his colleagues to update their chapters. Thus, the text incorporates not only lessons from the COVID-19 period, but also the effects of the Ukraine war, energy crisis, and inflation. And, obviously, the context of climate adaptation and its implications for Germany's sectors and regions are addressed everywhere. At the same time, Kulke has given his colleagues considerable freedom. As a result, not all chapters have the same structure or equal length, which one would expect from a textbook like this one. It is also unfortunate that introductory and concluding chapters on 'the big picture'

are missing. As a result, readers may search in vain for an overall vision on the economic geography of Germany. Perhaps this gap can be filled in a subsequent edition, if only to increase the potential readership of this fascinating book.

4. SUSTAINABILITY ISSUES

In an episode of the German SpacEconomics-Podcast, Sebastian Losacker (Leibniz University Hannover) clearly explains the background of the book *Nachhaltige Wirtschaftsgeographie* (Sustainable Economic Geography) that he wrote with his colleague Ingo Liefner: 'There is a global consensus that we as humanity want to achieve the Sustainable Development Goals. And we thought that economic geography could also make an important contribution' (*translation GJH*) (Braunschweig, 2023). With this idea in mind, both scientists have written a concise textbook in which they discuss sustainability from an economic geographical point of view. In doing so, they focus on both, socio-economic sustainability (intragenerative equality) and ecological sustainability (intergenerative equality).

The book has a clear structure and is divided into five chapters. After an introduction on the background and the definition of sustainable economic geography, the authors devote chapters 2 and 3 to socio-economic sustainability. Here, the causes and consequences of regional disparities are addressed with an emphasis on the influence of technology and innovation. For me, many familiar theories and concepts popped up, from agglomeration factors and regional polarisation to cluster approaches and knowledge spillovers. As someone trained in economic geography, only the theories on regional resilience, commodity chains and upgrading were real eye-openers for me. In my view, readers who want to know more on sustainable economic geography can better browse chapters 4 and 5.

Chapter 4 mainly deals with views from geographical transition research, a subfield of transition studies. Liefner and Losacker discuss the transition to an ecologically sustainable economy and the obstacles involved, such as the lock-in of environmentally polluting technologies. But they also discuss the lead markets of environmental innovations, the multi-level perspective, as well as the rebound effects of resource-saving technologies. In chapter 5, I read with great interest the sections on inclusive and frugal innovation and the consideration of alternative economic structures. Even though the authors discuss all kinds of radical economic approaches, it is clear that they – like myself – have doubts about whether these post-growth perspectives will gain a foothold in economic geography.

A strength of the book is that theory, empiricism and policy are all given full attention. This is not entirely coincidental, as Liefner and Losacker see their book as an update of the classic *Wirtschaftsgeographie* (2001, original edition: 1978) of

Schätzl, their teacher and former colleague, who also worked at the Leibniz University Hannover. It is a pity, however, that there is little focus on real-life cases that would make the material come alive more. This is particularly unfortunate because I think that the book's heavy focus on ecological sustainability (and thus the energy transition) makes it useful not only for students but also for policymakers. At a time when the German *Energiewende* (energy transition) needs a new impetus, the book offers stakeholders a handy overview of the opportunities and challenges for a climate-friendly future.

5. FROM PAST SUCCESSES TO A PROMISING FUTURE?

Traditionally, Germany is the largest economy of the EU-28: nearly a quarter of European gross domestic product is generated in this country. Mou sreover, after China and the USA Germany is the world's largest exporting nation. The three books under review suggest that the background for this achievement must be sought in a historically grown constellation of entrepreneurship, dedicated politics and a long-term vision. Germany's obsession with exports, its diverse industry mix with a relatively strong focus on manufacturing, as well as pioneering activities by policymakers and firms on sustainability make the country a sought-after trading partner. Yet the strength of the German economy is not a given: past successes do not guarantee a promising future. Or, as Bardt *et al.* (2023) noted in December 2023: 'The development of the global economy and inflation determine the general economic conditions for the German economy and therefore also the risks' (*translation GJH*). Some commentators go a step further and see the situation in Germany, particularly due to high energy prices, as an 'economic disaster in slow-motion' (De Jong, 2023).

Do the discussed books provide insights which Germany can use to get the national economy back on its feet? After reading them and reflecting on their main messages, I think so. For a start, the 'Made in Germany' label, which stands for quality, reliability and service, remains an important asset, especially in a global economy that is stumbling from crisis to crisis. Furthermore, Germany should better link its well-embedded manufacturing sector to future-oriented technologies, if only to remain competitive vis-à-vis the Chinese economy. If the German automotive industry is not careful, it might gradually be overtaken by Chinese companies entering the European market with cheap electric cars. With its long-standing experience in energy transition, it seems to me Germany could play a key role on a global scale in the field of environmental innovation. Important for this, however, is that German politics offer the business community a long-term horizon and do not get too distracted by incidents. After all, to invest, firms need certainty;

they need to know where they stand. Perhaps politicians would do well to invite the authors of *Exportweltmeister*, *Wirtschaftsgeographie Deutschlands*, and *Nachhaltige Wirtschaftsgeographie* to give a talk in the Reichstag in Berlin. That will not only be a very interesting meeting, but also one that might restore confidence, hope and perspective to the German economy.

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