https://doi.org/10.14669/AM/214647

CROSS-BORDER MOBILITY OF COMMUTERS IN THE CZECH-BAVARIAN REGION: EMPIRICAL INSIGHTS FROM BAVARIAN COMPANIES

DOMINIC SCHOLZE[1], CARMEN-RALUCA SPATACEANU[2], ONDREJ STOPKA[3], JIŘÍ HANZL[4], MÁRIA STOPKOVÁ[5], MAREN MARTENS[6]

Abstract

This study investigates economic structures, commuter patterns, and alternative mobility types, including electromobility, from the perspective of employers in the Czech–Bavarian border region, integrating quantitative data analysis with qualitative interview data provided by regional experts. The findings reveal persistent economic asymmetries motivating commuting flows, heavy reliance on private vehicles, and significant vulnerabilities exposed by recent border disruptions. Experts' insights emphasize the strategic importance of cross-border labor and the urgent need for integrated transport and labor market policies. This research advances theoretical understanding by linking labor market and transport infrastructures and provides practical recommendations for sustainable cross-border cooperation in the future. The novelty of the conducted research lies in its combined methodological approach. It merges quantitative commuting data with qualitative insights from regional experts, thereby capturing both structural patterns and lived realities in the Czech–Bavarian border region. In addition, it provides an integrated analysis of economic–,

1 Institute for Data and Process Science, Landshut University of Applied Sciences, Landshut, Germany, email: dominic.scholze@haw-landshut.de, ORCID: 0009-0005-4539-0588

2 Institute for Data and Process Science, Landshut University of Applied Sciences, Landshut, Germany, email: s-cspata@haw-landshut.de, ORCID: 0009-0009-5283-0667

3 Department of Transport and Logistics, Institute of Technology and Business in České Budějovice, Okružní 517/10, 37001, České Budějovice, Czech Republic, email: stopka@vste.cz, ORCID: 0000-0002-0932-4381

4 Department of Transport and Logistics, Institute of Technology and Business in České Budějovice, Okružní 517/10, 37001, České Budějovice, Czech Republic, email: hanzl@vste.cz, ORCID: 0000-0001-5121-9596

5 Department of Transport and Logistics, Institute of Technology and Business in České Budějovice, Okružní 517/10, 37001, České Budějovice, Czech Republic, email: stopkova@mail.vstecb.cz, ORCID: 0000-0001-6436-4047

6 Institute for Data and Process Science, Landshut University of Applied Sciences, Landshut, Germany, email: maren.martens@haw-landshut.de, ORCID: 0009-0000-9820-5888.

https://doi.org/10.14669/AM/214647

pattern-, and transport-mode-related aspects, including electromobility, from the Bavarian employers' standpoint. This offers a more holistic understanding of cross-border interdependencies.

Keywords: cross-border commuting; Czech–Bavarian labor mobility; mixed-methods research; Bavarian companies; electromobility

1. Introduction

Cross-border commuting has become a phenomenon shaping labor markets and regional development across Europe. In particular, the Czech–Bavarian border region is an example of cross-border labor flows due to economic disparities, demographic challenges, and a concentration of manufacturing industries such as the automotive industry. Bavarian companies increasingly rely on commuting workers from the Czech Republic to meet urgent skill shortages, which positions cross-border mobility as a key factor for regional competitiveness.

Despite these developments, the commuter system is highly dependent on private car usage, with a majority of cross-border commuters traveling by car. This reliance creates vulnerabilities, particularly exposed during border closures such as those implemented during the COVID-19 pandemic. Consequently, questions arise regarding the sustainability, resilience, and long-term viability of cross-border commuting as a labor supply solution.

While cross-border commuting has been the subject of extensive research in Europe, much of the literature focuses on macroeconomic issues and demographic drivers [1–3]. Specific emphasis on the employer-oriented dimension, how companies perceive and are affected by cross-border labor mobility, remains rare. As Tsiopa et al. highlight, sustainable commuter flows represent not only individual mobility choices but systemic conditions strongly tied to the complexity of the labor market and administrative or cultural differences [4]. In the Czech–Bavarian context, the employer perspective has not yet been systematically integrated into empirical analyses.

This study aims to fill this gap by investigating cross-border commuter mobility from the perspective of Bavarian employers. The research addresses the following research questions (RQ):

- RQ1: How do economic structures in the Czech–Bavarian area influence commuter flows?
- RQ2: What are the patterns and dynamics of commuting labor?
- RQ3: How do transportation modes affect those patterns and dynamics?

By combining quantitative data from official statistics with qualitative insights obtained through an expert interview, this paper contributes both empirical evidence and a nuanced understanding of the interdependence between labor markets and mobility infrastructures.

https://doi.org/10.14669/AM/214647

This article is structured as follows: Section 1 introduces the topic and reviews the literature on cross-border labor mobility, transport infrastructures, and employer perspectives. Section 2 outlines the mixed methodology employed. Section 3 presents empirical findings along the three research questions. Section 4 discusses the results in relation to existing research and theoretical frameworks, and finally, Section 5 concludes the study and recommends future research.

1.1. Cross-Border Labor Mobility

Cross-border labor mobility is a key mechanism for regional economic integration in the Czech–Bavarian border region, where structural imbalances encourage daily commuting [5, 6]. Comparative research in diverse border regions underlines how labor mobility functions as a buffer for skill shortages and demographic challenges [1]. More recent empirical evidence explores how exchange rate fluctuations additionally influence cross-border commuting decisions [7], while relatively low-level cooperation in the Czech–Polish labor market reveals the influence of the absence of a major economic engine on one side of the border [8].

1.2. Transportation Infrastructure and Modal Dependence

The development and availability of transportation infrastructure critically shape cross-border commuting. Car usage dominates due to insufficient, fragmented public transport offerings and poor coordination of services across borders [2, 4, 9]. This results in environmental pressures and systemic vulnerabilities, as illustrated during the COVID-19 border closures [10, 11]. Studies from the Alpine macro-region reflect similar dynamics where cross-border commuting patterns closely depend on urbanization and morphology of the regions, i.e., the presence of metropolitan or mountain regions [12]. Furthermore, emerging mobility modes and technologies, including electrified and shared vehicles, offer potential but currently remain underutilized in cross-border contexts [13].

1.3. Employer Perspective in Labor Mobility Research

The employer perspective in cross-border commuting remains insufficiently illuminated in existing literature, despite its critical relevance. While much research addresses commuters' individual motivations and socioeconomic outcomes, relatively few studies analyze employer strategies related to workforce mobility in cross-border regions. Studies focusing on other European border regions, including German–Danish and Dutch–German areas, demonstrate the importance of employers' roles in shaping cross-border labor markets and highlight cooperation in vocational training and recruitment partnerships [14]. Given the dependency

https://doi.org/10.14669/AM/214647

of cross-border workers on specialized sectors such as the automotive industry, understanding employer dynamics is imperative to formulate effective labor and transport policies [15].

1.4. Synthesis and Research Gap

Although cross-border labor mobility and transport infrastructure are well-examined independently, integrating these perspectives with employer viewpoints remains a research frontier. The intersection of economic disparities, transport conditions, and employer strategies forms a critical, yet underexplored research field for understanding regional development and labor market resiliency [16, 17]. Recently, systematic literature reviews have begun to emphasize this integrative need, advocating for more comprehensive approaches that include employer insights alongside quantitative flow analyses [4]. This article responds to that call by focusing on the Czech-Bavarian border's unique challenges and potentials through a mixed-method approach combining qualitative interview data and quantitative statistics.

2. Methodology

2.1. Research Design

This study employs a mixed-methods research design using an explanatory sequential approach, integrating quantitative and qualitative methods to comprehensively investigate cross-border commuting dynamics. Initially, quantitative data analysis identifies trends, economic disparities, and transport infrastructure, followed by qualitative expert interviews, which contextualize and deepen interpretation by capturing employer perspectives. The mixed-methods approach balances the strengths and limitations of both methods, ensuring a fuller and more credible understanding of the research problem [18, 19].

2.2. Quantitative Component

Quantitative data employed in this study were drawn from multiple official sources:

- German Federal Employment Agency (in German: Bundesagentur für Arbeit): Employees subject to social security contributions at the place of work by nationality [20].
- Bavarian State Office for Statistics: GENESIS database [21] and Czech Statistical Office: Regional accounts [22].
- Bavarian State Office for Statistics: Socially insured employees at the workplace in selected Bavarian districts with residential addresses in the Czech Republic 2013–2024 [23].

https://doi.org/10.14669/AM/214647

- Bayern Innovativ GmbH: Quarterly Report Q1 2025 on Electromobility in Bavaria, providing data on electric vehicle registrations, charging infrastructure, and market trends in Bavaria [24].
- European Commission, European Alternative Fuels Observatory: Report on record battery electric vehicle (BEV) registrations in Czechia in June 2024, highlighting the surge in BEV adoption and market share increase [25].

The temporal coverage of the dataset spans 2013–2024, enabling a decade-long analysis of the evolution of cross-border labor mobility and corresponding industrial and infrastructural developments.Data were compiled at the NUTS-2 regional level, including Bavarian districts (Upper Palatinate, Lower Bavaria, Upper Franconia) and corresponding Czech border regions (Karlovy Vary, Pilsen, South Bohemia). The dataset integrates the following quantitative variables:

- Number of Czech residents employed in Bavaria and subject to German social security contributions.
- Regional GDP per capita (in EUR, constant prices).
- Modal split indicators (car vs. public transport, where available).
- Electric vehicle penetration (share of BEVs and PHEVs among new car registrations).

Data harmonization steps included unit conversion (CZK to EUR). Data aggregation and visualization were performed using Microsoft Excel, enabling both tabular trend analysis and spatial representation.

The quantitative analysis followed a linear, exploratory structure:

1. Identification of structural disparities in GDP per capita and wage levels between Bavarian and Czech border regions.
2. Visualization of commuting volumes and growth rates to determine temporal patterns of increasing cross-border labor mobility.
3. Review of publicly available modal split data and secondary literature to infer dominant travel modes among cross-border commuters.
4. Integration of EV registration and infrastructure data with commuting flows to identify the potential intersection between labor mobility and sustainable transport uptake.

However, the analysis is constrained by the availability and granularity of cross-border transport data. Official statistics do not consistently report modal split or vehicle type at the commuter level, making it necessary to triangulate quantitative results with findings from existing regional studies. Despite these limitations, the multi-source dataset ensures robustness by cross-verifying records from German and Czech authorities.

https://doi.org/10.14669/AM/214647

2.3. Qualitative Component

A semi-structured expert interview with representatives from a regional cross-border organization was conducted, lasting approximately 120 minutes (Project LUABA [26], February 2025). The transcribed interview was analyzed using Mayring's qualitative content analysis approach [27], which involves systematic, rule-guided coding to identify themes such as economic structure, commuting patterns, and transportation modes. This approach provides rich contextual insights to complement and explain the quantitative findings [28–30].

2.4. Data Integration

Following the explanatory sequential design, quantitative results are initially presented and complemented by qualitative insights to enable triangulation and a better understanding of the multi-dimensional nature of cross-border commuting [19]. This integrative procedure enhances internal validity and provides a more nuanced view of the challenges and potentials seen by employers in the border region.

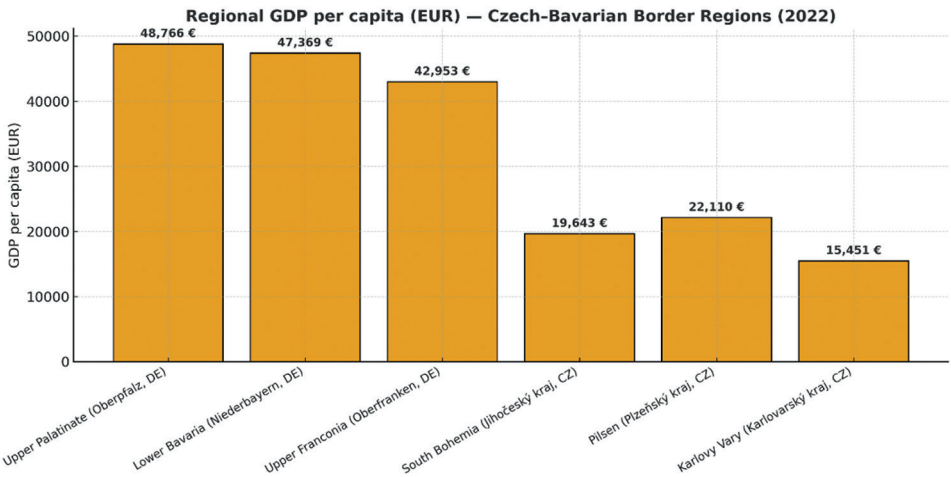
3. Results

This section presents the empirical findings organized along the study's three main research questions: economic structure (RQ1), commuter patterns (RQ2), and transportation modes (RQ3). The analysis integrates data from regional experts, secondary statistical sources, and document analysis.

3.1. Economic Structure (RQ1)

1) Quantitative Findings:
The economic landscape in the Czech–Bavarian border region reveals persistent disparities despite signs of gradual convergence [3]. According to the Bavarian State Ministry for Economic Affairs, Regional Development, and Energy, Gross Domestic Product (GDP) per capita and average wages remain substantially higher on the Bavarian side, which incentivizes cross-border commuting [5], see Figure 1. The districts of Upper Palatinate, Lower Bavaria, and Upper Franconia differ markedly in economic strength when compared to adjacent Czech regions such as Karlovy Vary and South Bohemia, which show lower income levels and less diverse industrial bases [1]. This economic asymmetry is a fundamental driver of cross-border labor flows [31].

https://doi.org/10.14669/AM/214647



Explanatory notes: Data (2022): Bavarian regional statistics for Oberpfalz, Niederbayern, Oberfranken; Czech Statistical Office (ČSÚ) regional accounts for Jihočeský, Plzeňský and Karlovarský kraj. CZK to EUR conversion used annual average

Fig. 1. Reginal GDP per capita (EUR) – Czech–Bavarian cross–border regions under investigation [21, 22]

Based on the findings from Figure 1, it can be concluded that the numbers illustrate the economic asymmetry of the examined parameter (i.e., GDP): Bavarian subregions show much higher GDP per capita (in EUR) than the adjacent Czech regions.

2) Qualitative Findings:

Interviews with regional economics experts underscore that Czech cross–border workers constitute an essential component of regional labor markets. Representatives from small and medium–sized enterprises (SMEs) in the automotive supply and metalworking sectors stress the critical role of Czech commuters in filling skill shortages, especially for technically qualified positions and apprenticeships. Companies report that without these workers, recruitment difficulties would intensify, threatening production capacities and growth. Qualitative findings further reveal significant structural features of the Bavarian–Czech border region's economy. Experts note that, alongside the automotive sector, which faces acute crises due to declining orders, metalworking, furniture, plastics, and notable firms rely heavily on Czech employees, who often undertake physically demanding or less desirable shift work. In the services sector, Czech staff are crucial in health care, elderly care, and social services, often accepting roles unattractive to German workers due to lower wages or demanding conditions. This dependence was especially pronounced during the COVID–19 pandemic, when these sectors were classified as strategic and continued cross–border commuting was enabled.

https://doi.org/10.14669/AM/214647

The transport and logistics sector experiences a shortage of drivers, primarily Czech long-distance and bus drivers. Carpooling is widespread, especially among employees of large companies. Across interviews, the persistent and structural shortage of skilled personnel was described as a region-wide problem, affecting all industries and intensified by low unemployment in Czechia. While the need for low-skilled manual labor is particularly high in manufacturing and hospitality, sectors in which Czech workers fill gaps left by a lack of interest from German employees, the health and social services were repeatedly cited as especially dependent on cross-border workforce influx, with demographic trends in both countries indicating growing long-term demand.

The regional labor market is shaped by several large employers significantly dependent on Czech labor, as well as an increasing diversification as companies shift towards the defense industry to offset declines in automotive stability. International investors and company size further impact stability and employment prospects, and there are visible regional disparities: while the border area is dominated by large industrial employers and low unemployment, other regions in Czechia exhibit higher unemployment and fewer prominent workplaces.

3) Data Integration and Interpretation:
Triangulating these quantitative findings, interviews with regional economics experts underscore the critical role of Czech cross-border workers for regional labor markets. Representatives from SMEs in the automotive supply and metalworking sectors emphasize that Czech commuters fill essential skill shortages, particularly in technically qualified roles and apprenticeships. Without these cross-border workers, recruitment difficulties would likely intensify, threatening production capacities and overall growth.

3.2. Commuter Patterns (RQ2)

1) Quantitative Findings:
Secondary data show a significant increase in Czech cross-border commuters to Bavaria, growing from approximately 7,500 in 2013 to over 23,000 by 2023 in the districts of Upper Palatinate, Lower Bavaria, and Upper Franconia [23], see Figure 2. The trend maintains an upward trajectory, particularly affecting districts near the border. Data reveal employment concentration in rural and semi-rural districts, with commuters frequently employed in industrial zones and expanding manufacturing firms [2].

https://doi.org/10.14669/AM/214647

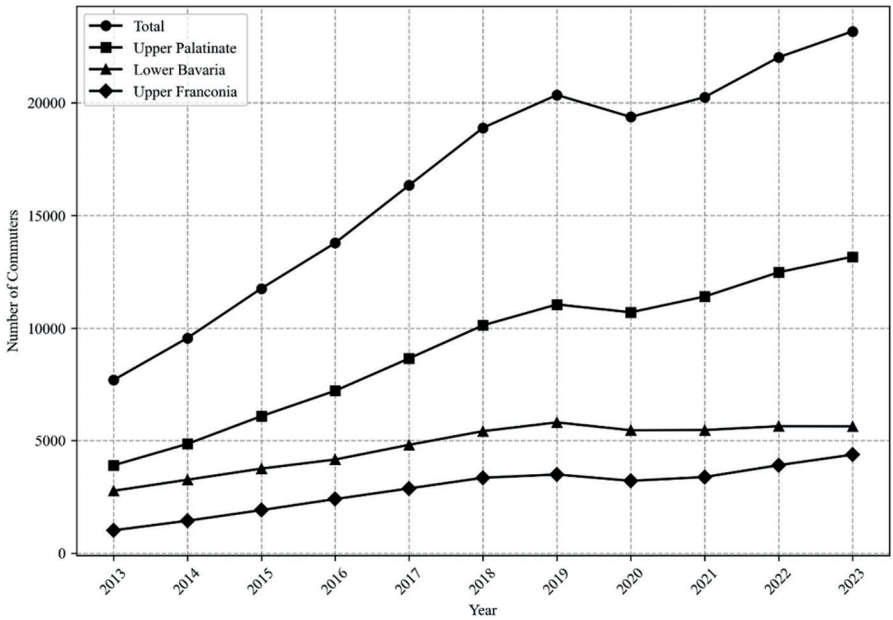


Fig. 2. Development of Czech cross-border commuters in the Bavarian districts of Upper Palatinate, Lower Bavaria, and Upper Franconia [23]

2) Qualitative Findings:

Expert interviews highlight several geographic focal points for cross-border employment in the Bavarian-Czech region. Border districts such as Cham, Regen, Freyung-Grafenau, and Passau are key destinations, each hosting major manufacturing plants, including leading firms like Zollner in Cham, Knaus Tabbert in Jandelsbrunn, Rohde & Schwarz, and Schock in Regen. These enterprises are significant attractors for Czech workers, with operations that commonly include both day and night shifts. The city of Passau also stands out, historically served by a dedicated commuter bus line linking it to Strakonice and Vimperk. Outside the industrial sector, service and hospitality businesses in towns such as Zwiesel and Bodenmais provide additional employment opportunities, particularly for workers from Klatovy. The interviews further indicate that Austria, Lipno and seasonal winter employment areas, are relevant targets for Czech cross-border labor.

The origins of Czech cross-border workers are heterogeneous. Interviewees cite both border-near towns (e.g., Vimperk, Strakonice) and more distant urban centers (e.g., Budweis, Pilsen) as sources of commuters. Historical infrastructure, such as dedicated commuter bus routes, as well as current international rail lines (e.g., Munich–Prague), facilitate mobility over average distances of approximately 34 kilometers and commute times of about 1.5 hours. The feasibility of cross-border commuting is directly related to distance, with routes from

https://doi.org/10.14669/AM/214647

more remote areas posing a practical challenge. Vimperk emerges as a recurring point of aggregation for carpooling and public transit, and Pilsen is also highlighted as a hub for longer-distance commuting toward Bavarian workplaces.

Since the opening of the border, commuter flows have risen appreciably, with experts noting a steady increase rather than a post-2011 surge. Significant events such as the COVID-19 pandemic and economic downturns have caused temporary reductions in commuter numbers, whereas periods of economic expansion and heightened labor demand have fostered growth. Proximity to the border is a decisive factor, with cross-border commuting most prevalent in areas like the Pilsen district and Cham County. Key infrastructural factors, such as travel time, transport connectivity (including car, bus, and train), shape mobility patterns, and language differences are recognized as an additional moderating influence. Automation, especially in manufacturing, is also cited as a factor potentially controlling future commuter growth. Social network effects support further increases, as individuals often follow friends or family into cross-border employment, with large companies now employing several hundred Czech workers.

3) Data Integration and Interpretation:
Qualitative insights from regional experts complement the quantitative figures by identifying key geographic focal points of employment, including Cham, Regen, Freyung-Grafenau, and Passau, which host major manufacturing plants such as Zollner, Knaus Tabbert, Rohde & Schwarz, and Schock. These companies offer both day and night shifts, strengthening their role as principal attractors for Czech commuters. Additionally, service and hospitality sectors in towns like Zwiesel and Bodenmais provide employment opportunities, highlighting a degree of labor market diversification. Cross-border commuting extends beyond Germany, with Austria cited for seasonal and permanent work, reflecting broader regional mobility.

3.3. Transport Modes (RQ3)

1) Quantitative Findings:
Most cross-border commuters predominantly rely on private vehicles, reflecting limited public transport alternatives in the region. The fragmentation of bus and train services across national borders, inconsistent schedules, and tariff complexities limit the attractiveness of collective transport. Comprehensive official modal split data specific to Czech–Bavarian cross-border commuters remain scarce in publicly accessible statistical reports. The Bavarian State Office for Statistics and regional development studies report rising commuter flows but often do not detail exact transport mode shares [32].

However, broader European and border region research consistently finds that the majority of cross-border commuters rely on private vehicles. The adoption of electric vehicles remains relatively low but has the potential to grow, particularly in peripheral or rural border regions

https://doi.org/10.14669/AM/214647

where public transport connectivity is limited [33]. Private car usage is the predominant commuter mode, as travel distances, shift work, and sparse public transport options limit collective transport's feasibility [2, 33, 34]. Studies cite the lack of harmonized cross-border public transport tariffs and schedules as a significant obstacle, making public transport less competitive compared to private cars [3]. This pattern also applies to the Bavarian-Czech border area, characterized by fragmented public transport and infrastructural barriers [1]. Current estimates suggest public transport accounts for a marginal share (under 5%) of cross-border commuting trips in comparable regional contexts with similar geography and economic structures [33].

2) Qualitative Findings:
Expert interviews confirm that private cars, including electromobiles, often in the form of carpools, are the predominant mode of cross-border commuting for Czech workers. Although buses and minibuses once played a larger role, many routes have been discontinued or reduced in service, with public transit now considered insufficient for everyday commuting needs. The most significant commuter routes use main border crossings such as Furth im Wald, which is described as notably more convenient than smaller checkpoints. While railway connections exist, for example, Bayerisch Eisenstein with a link to Železná Ruda, these are regarded as less practical due to limited schedules and lengthy travel times. Major roadways like the B12 both shape commuting patterns and attract businesses that employ Czech workers. Notably, despite some efforts to support cross-border mobility through train and bus services, the reliability and compatibility of schedules with shift work remain limited. Consequently, private vehicles are regarded as the simplest and most dependable commuting option, while carpooling, though highlighted for its cost-reducing benefits, is reported as only moderately widespread.

The necessity for many families to own two cars is identified as a substantial financial burden, with expenses including purchase, maintenance, fuel, and repairs. The removal of previously subsidized bus lines and monthly tickets, formerly supported by employers, has been described as making the situation less affordable for commuters. On the positive side, cross-border workers can take advantage of lower prices for certain goods in Germany, providing some relief to household budgets. Time costs also weigh heavily: long commutes are further complicated by natural barriers such as national parks or a lack of crossings, necessitating detours. For longer distances, relocation or weekly commuting (renting accommodation near the workplace) is considered more economical, with employer-provided housing occasionally mitigating costs and the daily travel burden.

The interviewees stress the crucial role of well-coordinated connections for public transit, as demonstrated in Bayerisch Eisenstein, where streamlined train transfers lead to higher trust in public transport. Tailored bus lines (e.g., Strakonice–Vimperk–Passau) were praised for their high comfort and alignment with workers' schedules, but widespread discontinuation of such services has reduced overall attractiveness and feasibility. In contrast, inconvenient

https://doi.org/10.14669/AM/214647

services, such as bus lines with excessive stops or train routes with very limited departures, are cited as impractical for regular commuters. The car is universally regarded as more comfortable and reliable, reinforcing its dominance where feasible alternatives are lacking.

Cultural distance and initial post-border-opening differences have given way to professional and even friendly relationships between Bavarian and Czech employees. A shared work ethic and mutual respect were emphasized, with mixed families and bilingual solutions enhancing integration. Nevertheless, language barriers persist as a key challenge affecting workplace integration and collaboration. The presence of bilingual staff and coordinators is seen as a significant advantage, improving project outcomes and job prospects. Social networks expand as cross-border workers recruit acquaintances and family members, further strengthening ties and regional exchanges.

3) Data Integration and Interpretation:
Qualitative insights from expert interviews confirm the quantitative findings and provide further context. Private car travel is the main commuting mode, often facilitated through carpooling, though the latter remains moderately widespread. Historic bus lines and mini-buses have declined, and remaining rail connections, such as Bayerisch Eisenstein to Železná Ruda, offer limited schedules incompatible with shift work. Commuters rely heavily on key crossings like Furth im Wald and main roads like the B12, which also serve as industrial hubs employing many Czech workers.

This car's dependency poses sustainability and operational risks. Employers increasingly advocate for integrated mobility governance and infrastructure improvements to diversify commuting options and reduce carbon footprints. Companies with proactive mobility programs (carpooling, shuttle vans) report better employee satisfaction and lower absenteeism.

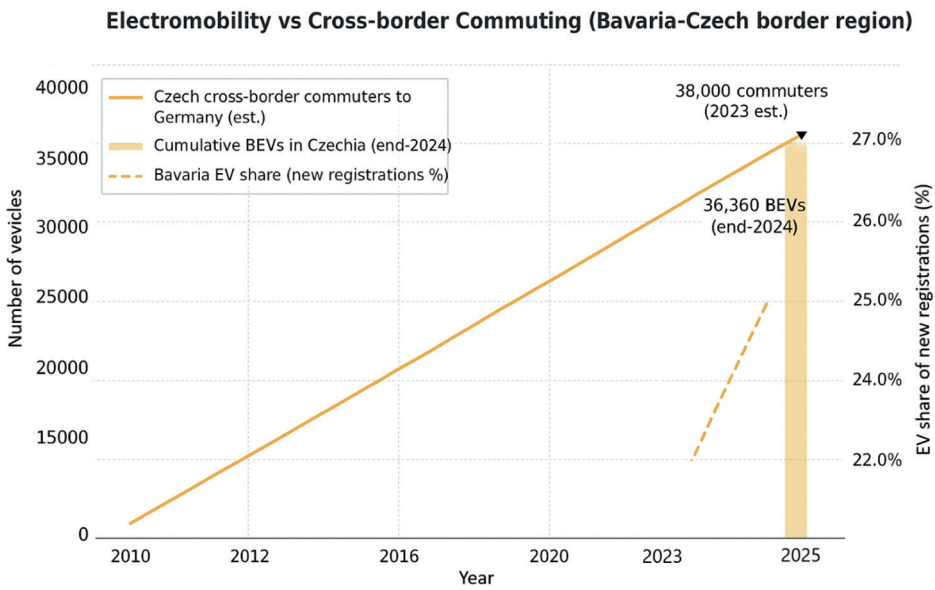
4) Electromobility
Recent data from Bavaria and the Czech Republic [24, 25] shows that while electromobility is growing quickly, its penetration among cross-border commuters remains limited, reinforcing the dominance of private vehicles for everyday commuting, especially in regions with weak public transport. In Bavaria, electric vehicles (battery electric and plug-in hybrids) accounted for 25.1% of all new registrations in Q1 2025; pure battery electric vehicles (BEVs) alone were 16.3%. Charging infrastructure is also expanding: over 32,000 publicly accessible charging points by early 2025 in Bavaria [24].

Meanwhile, in the Czech Republic, there has been a record month (June 2024) with over 1,500 new BEV registrations, pushing that segment's market share to nearly 7%. Across the Czech Republic more generally, more than 27,600 BEVs are now in operation, supported by over 5,200 public charging points nationwide [25].

https://doi.org/10.14669/AM/214647

These numbers indicate that, even in a landscape where private vehicles remain the default mode for cross-border commuting, electromobility is making inroads. However, there is no current evidence that the share of BEVs or PHEVs among cross-border commuter trips reaches anything like the 25% share Bavaria is seeing in new registrations overall. Most commuters are still relying on conventional private vehicles. This gap suggests that the main barriers remain: availability (charging, fast charging), schedule and cost of alternatives (public transit), and alignment with shift work timing.

The Figure 3 depicts the relationship between cross-border commuting flows from the Czech Republic to Bavaria and the uptake of electromobility in the region. The chart combines commuter counts with the growth of battery-electric vehicles (BEVs) in the Czech Republic and the rising share of EV registrations in Bavaria, showing: (1) the absolute scale of cross-border commuting from the Czech Republic into Germany and the national BEV fleet in the Czech Republic are of the same order of magnitude (tens of thousands), and (2) Bavaria's new-car market has already reached mid-20s percent EV penetration (22% in Q2–2023; 25% in Q3–2024).



Explanatory notes:

Left axis (counts): a 2010 ⟶ 2023 commuter trend (~3,800 ⟶ ~38,000) and a bar for the Czech BEV (≈36,360 vehicles, end-2024).

Right axis (percentage): Bavaria EV share of new registrations (22% Q2-2023; 25% Q3-2024).

Fig. 3. Electromobility vs Cross-border Commuting (Bavaria–Czech border region) [24, 25]

https://doi.org/10.14669/AM/214647

The chart above shows two related realities: (1) the absolute scale of cross-border commuting from the Czech Republic into Germany and the national BEV fleet in the Czech Republic are of the same order of magnitude (tens of thousands), and (2) Bavaria's new-car market has already reached mid-20s percent EV penetration (22% in Q2–2023; 25% in Q3–2024). Specifically, regional reporting states over 38,000 Czech cross-border commuters to Germany in 2023 (most concentrated in Bavaria and Saxony), while Czechia's BEV stock surpassed ~36,000 BEVs by the end of 2024. This combination means that even if Bavarian firms and commuters shift toward EVs rapidly, the current commuter population still largely travels by private (mostly non-electric) car. Electrifying cross-border commuting will require (a) targeted incentives for commuters to adopt BEVs, (b) charging infrastructure along key corridors and at workplaces, e.g., main crossings such as Furth im Wald and arterial routes like the B12, and (c) employer-led mobility measures such as workplace chargers, shuttles, regulated car-sharing or carpool EV fleets that align with shift schedules [24, 25].

This highlights a clear policy window: Bavaria's fast uptake of EVs, i.e., percent of new registrations, creates an enabling environment, but converting the existing commuter fleet – the tens of thousands who cross daily or weekly – depends on infrastructure and programmatic interventions rather than market momentum alone.

4. Discussion

This section discusses the empirical findings of the study in relation to existing scholarly literature and theoretical frameworks on cross-border commuting, regional economic disparities, and transport infrastructure. The aim is to situate the evidence from the Czech–Bavarian border within broader academic debates and conceptual models, while emphasizing the distinct employer perspective revealed by our mixed-method approach.

4.1. Economic Disparities and Cross-Border Commuting: Theoretical Perspectives

The persistent economic asymmetries demonstrated between Bavarian and Czech border regions confirm the central role of classical economic theories in explaining cross-border commuting. The neoclassical framework, grounded in human capital theory, posits that differential wage opportunities constitute the primary pull factor for cross-border workers seeking to maximize income [35–37]. Our findings resonate with this understanding: higher wages and better economic conditions in Bavaria create strong incentives for Czech workers to commute daily across the border, especially in sectors facing skill shortages such as automotive and engineering.

However, the findings also illustrate limitations of purely economic rational-choice models. Qualitative data suggest that employer concerns about potential wage convergence and institutional differences affect long-term labor mobility dynamics. This echoes more recent, multidimensional approaches that incorporate non-economic factors such as institutional and language barriers, mental thresholds, and social integration influencing commuting decisions [38–40]. Institutional and infrastructural differences between Germany and the Czech Republic act as both barriers and mediators of commuting flows, highlighting the complexity beyond wage differentials [41, 42].

4.2. Transport Infrastructure and Modal Dependence in Border Regions

Our findings indicate the critical bottleneck that transport infrastructure represents for cross-border mobility, consistent with previous research emphasizing the dominance of car-based commuting in peripheral and cross-border regions [33]. The very low modal share of public transport among commuters found in the Czech–Bavarian case reflects systemic fragmentation: poorly coordinated timetables, incompatible tariff systems, and limited frequency reduce the attractiveness of collective transport options.

This situation typifies the broader sustainability challenges documented in cross-border travel literature [12]. Car dependence not only contributes to environmental externalities but also creates fragility, especially during border closures or transport disruptions, as highlighted by the COVID-19 pandemic experiences reported by employers [10, 11]. Policy responses must therefore focus on integrated cross-border governance of transport infrastructure, including tariff harmonization and multimodal alternatives, to enhance resilience and sustainability.

4.3. Employer Perspective: Linking Labor Market Dynamics and Mobility

Another contribution of this study is highlighting the employer perspective, a somewhat neglected angle in cross-border mobility research until now. Firms' recognition of Czech commuters, as essential to their labor supply, aligns with prior studies underlining the economic significance of cross-border workers in key industries. The employer's view also brings to light strategic challenges, such as workforce retention, transport barriers, and the implications of political volatility.

This perspective enriches theoretical models by highlighting commuting as an institutional vulnerability: companies depend on mobility infrastructures and policies beyond their direct control, introducing external risks into labor supply management. It extends labor market and mobility frameworks to incorporate actors' strategic adaptations and infrastructure

https://doi.org/10.14669/AM/214647

dependencies, bridging gaps between economic geography, regional policy, and organizational studies.

4.4. Company Size, Sector, and Location: Differential Impacts

The analysis shows the differentiated impacts of cross-border commuting patterns by company characteristics. SMEs, particularly in specialized manufacturing and supply chain sectors, appear more reliant on cross-border workers, which corresponds with prior findings that smaller firms often lack internal resources to compensate for labor shortages internally. Larger companies may have more diversified recruitment strategies but still depend significantly on commuter flows.

Geographically, firms located in border-proximate districts face distinct commuting dynamics compared to those in more central urban areas, echoing spatial economic models that emphasize the importance of proximity and accessibility for labor mobility. Regional transport and infrastructure policies thus must be tailored to local company structures and sectoral profiles, optimizing support for cross-border commuting depending on firm and location-specific needs.

4.5. Policy Implications

The empirical findings and theoretical reflections point to several policy implications for fostering sustainable and resilient cross-border commuting in the Czech–Bavarian border region. These implications align with broader EU and regional strategies [43] but require tailored implementation sensitive to local structural and institutional contexts.

The dominance of private vehicle use underscores the urgent need for integrated, multimodal transport solutions. Policymakers should prioritize the coordination and harmonization of public transport systems across the Bavarian–Czech border, addressing deficiencies such as fragmented timetables, incompatible fare systems, and low service frequencies. Investments in rail and bus connections, combined with employer-supported shuttle systems, can reduce reliance on cars and improve labor market accessibility. Interregional cooperation platforms like EUREGIO EGRENSIS could be strengthened to act as coordinating bodies for cross-border transport governance. Such a multi-level cooperation should incorporate employers as key stakeholders to ensure policies respond directly to workforce mobility needs and employer challenges [44]. Such integrated governance is crucial to enhance system resilience against future disruptions like pandemic border controls.

Employers, especially SMEs facing acute labor shortages, should be supported in developing mobility-sensitive human resource strategies. Public funding and advisory services could

facilitate company-based mobility programs such as carpooling, flexible shift scheduling aligned with public transport, and transport subsidies for cross-border commuters. Furthermore, regional workforce development policies should integrate transport considerations, recognizing commuting as an essential element of recruitment and retention. Enhanced collaboration between labor market agencies, transport planners, and business associations is recommended to design sustainable and inclusive mobility solutions.

Policy should aim to deepen structural integration across the border by supporting economic diversification and cluster development on both sides. This could reduce disparities that drive one-way labor flows and foster complementary development patterns. Spatial planning policies need to be aligned bi-nationally to account for commuting corridors, labor market zones, and transport infrastructure investments [44]. Finally, EU-level frameworks such as INTERREG and the European Cohesion Policy offer funding and strategic guidance to further support cross-border mobility and cooperation. Active leveraging of these initiatives, coupled with local stakeholder engagement, is advised to maximize the sustainable development of the Czech–Bavarian frontier.

4.6. Limitations

This study faces certain limitations. The qualitative sample size is small, limiting representativity but allowing an in-depth exploration of employer perspectives. Quantitative data, while rich and spanning multiple years, extend only to 2024 and may not fully reflect COVID-19's long-term effects on mobility patterns. Despite these constraints, the mixed-methods strategy enables a balanced and robust analysis of the study's key questions. Future research should include wider interview samples and incorporate real-time mobility data sources to improve timeliness and applicability [45].

5. Conclusions

This study set out to investigate cross-border commuting dynamics in the Czech–Bavarian border region, focusing on three research questions: economic structural drivers (RQ1), commuter patterns (RQ2), and transport alternatives (RQ3). The analysis confirms that economic asymmetries, notably wage and productivity differentials, remain a primary driver of commuting flows, especially into Bavarian industrial sectors. Czech commuters constitute a vital labor supply for regional SMEs and manufacturing firms, helping to mitigate skill shortages and sustain production capacities. The pattern of commuter flows shows strong geographic concentration near border districts, with substantial increases documented over the last decade. However, this system is fragile and exposed to border policy changes, as COVID-19 mobility restrictions demonstrated. The study further reveals a high dependence on private vehicle use among cross-border commuters, reflecting fragmented public trans-

port systems with limited integration and low modal shares. This dependency brings environmental challenges and systemic vulnerabilities. A core contribution of this research lies in integrating the employer perspective, which highlights commuting as an institutional vulnerability and strategic labor management challenge that extends prior individual-centered research. Employers also emphasize the need for coordinated transport and labor market policies to stabilize the cross-border workforce.

Future empirical studies should enlarge qualitative samples, incorporate real-time mobility data, and adopt comparative designs across different border regions to validate and extend findings. A deeper exploration of the effects of new mobility technologies and telecommuting on cross-border labor dynamics addresses the intertwined challenges of regional labor markets and mobility infrastructures in an increasingly interconnected Europe.

6. Acknowledgement

This work is supported by the Bavarian-Czech Academic Agency (BTHA) as part of the project "Analysis and optimization of the Czech-German commuting traffic to promote cross-border co-operation (Locomotion)" (German project number: BTHA-JC-2024-09; Czech project number: LUABA24085 within the INTER-EXCELLENCE II program, INTER-ACTION subprogram).

7. Nomenclature

COVID-19	Coronavirus disease 2019
RQ	Research question
SMEs	Small and Medium-sized enterprises

8. References

[1] Grontmij. Development Assessment for the Bavarian-Czech Border Region (Entwicklungsgutachten für den bayerisch-tschechischen Grenzraum). Munich: Grontmij GmbH (Contractor); 2015.

[2] Chamber of Industry and Commerce for Lower Bavaria in Passau (Industrie- und Handelskammer für Niederbayern in Passau). Commuter Flows 2020: Mobility in the World of Work (Pendlerströme 2020: Mobilität in der Arbeitswelt). 2020.

[3] Zumbusch K, Zwicker-Schwarm D, Skoda J, Tyrychtrová T. Socioeconomic Analysis for the Interreg Program VI-A Bavaria-Czech Republic 2021-2027 (Sozioökonomische Analyse für das Interreg Programm VI-A Bayern Tschechien 2021-2027). 2020. Available from: https://www.alexandria.unisg.ch/entities/publication/e0e504ae-5eaf-49bc-a25e-c35e5fb60d04 (accessed on 2025 Aug 26).

[4] Tsiopa A, Gerber P, Caruso G. Framing the cross-border commuting literature: a systematic review and bibliographic analysis. Transport Reviews. 2024;44(4):889–911. https://doi.org/10.1080/01441647.2024.2345623.

[5] Bavarian State Ministry for Economic Affairs, Regional Development and Energy (Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie). INTERREG BAYERN-TS-CHECHIEN 2021–2027. Managing Authority of the INTERREG Bavaria-Czech Republic Programme (Verwaltungsbehörde des Programms INTERREG Bayern-Tschechien) 2021–2027. 2022.

[6] Karacan E. Exploring cross-border labor commuting as a practice of tactical mobility. Border & Regional Studies. 2023;11:61–88. https://doi.org/10.25167/brs5112.

[7] Bello P. Exchange rate effects on cross-border commuting: evidence from the Swiss–Italian border. Journal of Economic Geography. 2020;20(4):969–1001. https://doi.org/10.1093/jeg/lbz025.

[8] Böhm H, Opioła W. Czech–Polish Cross-Border (Non) Cooperation in the Field of the Labor Market: Why Does It Seem to Be Un-De-Bordered? Sustainability. 2019;11(10):2855. https://doi.org/10.3390/su11102855.

[9] Cavallaro F, Dianin A. Efficiency of public transport for cross-border commuting: An accessibility-based analysis in Central Europe. Journal of Transport Geography. 2020;89:102876. https://doi.org/10.1016/j.jtrangeo.2020.102876.

[10] Haist J, Novotný L. Moving across Borders: The Work Life Experiences of Czech Cross-border Workers during the COVID-19 Pandemic. Journal of Common Market Studies. 2023;61(1):124–142. https://doi.org/10.1111/jcms.13362.

[11] Novotný L. Effects of 'Covidfencing' on cross-border commuting: a case of Czech–German borderland. European Planning Studies. 2022;30(4):590–607. https://doi.org/10.1080/09654313.2021.1986470.

[12] Chilla T, Heugel A. Cross-border Commuting Dynamics: Patterns and Driving Forces in the Alpine Macro-region. Journal of Borderlands Studies. 2019;37(1):17–35. https://doi.org/10.1080/08865655.2019.1700822.

[13] Compostella J, Fulton LM, Brown AL, De Kleine R, Kim HC, Wallington TJ. Travel time costs in the near-(circa 2020) and long-term (2030–2035) for automated, electrified, and shared mobility in the United States. Transport Policy. 2021;105:153–165. https://doi.org/10.1016/j.tranpol.2020.12.014.

[14] Wilde S, Kremer H, Stelzer J. Crossing Borders, Opening Minds? VET Tandem Partnerships in a Dutch-German Cross-Border Region. International Journal of Research in Vocational Education and Training. 2025;12(1):20–47. https://doi.org/10.13152/IJRVET.12.1.2.

[15] Mejía Dorantes L, Allen H. A review of the future transport labour market: An EU approach. European Transport Studies. 2024;1:100007. https://doi.org/10.1016/j.ets.2024.100007.

[16] Illing H. Crossing Borders: Labor Market Effects of European Integration. Rochester, NY: Social Science Research Network. IZA Discussion Paper. 2023;15930:1–113. https://doi.org/10.2139/ssrn.4354407.

[17] Van der Valk J. Border region data collection [Internet]. European Commission; 2018. Available from: https://www.euro-ace.eu/sites/default/files/attached_documents/Border%20region%20data%20collection%20final%20report..pdf (accessed on 2025 Aug 26).

[18] Lupták V, Stopka O, Hanzl J, Kampf R, Gross P, Scholze D, Martens M. Proposal for Data Retrieval Methodology in Terms of Cross-border Commuter Mobility: A Perspective of Czech Employees. Periodica Polytechnica Transportation Engineering. 2025;53(4):455–61. https://doi.org/10.3311/PPtr.40852.

[19] Creswell JW, Hirose M. Mixed methods and survey research in family medicine and community health. Family Medicine and Community Health. 2019;7:e000086. https://doi.org/10.1136/fmch-2019-000086.

[20] German Federal Employment Agency (Bundesagentur für Arbeit). Social security-contributing employees at the workplace by nationality (Sozialversicherungspflichtig Beschäftigte am Arbeitsort nach Staatsangehörigkeit) [Internet]. Nuremberg: Statistics of the Federal Employment Agency; 2024 Dec. Report No.: Order number 147037. Available from: https://statistik.arbeitsagentur.de (accessed on 2025 Aug 26).

[21] Bavarian State Statistical Office (Bayerisches Landesamt für Statistik). GENESIS-Online Database. 2025. Available from: https://www.statistikdaten.bayern.de/genesis/online (accessed on 2025 Feb 7).

[22] Czech Statistical Office (ČSU; Český statistický úřad). Regional accounts. 2025. Available from: https://csu.gov.cz/regionalni-ucty?pocet=10&start=0&podskupiny=054&razeni=-datumVydani (accessed on 2025 Feb 7).

[23] Bavarian State Statistical Office (Bayerisches Landesamt für Statistik). Social insurance-contributing employees by place of work in selected districts of Bavaria with residence in the Czech Republic for the years 2013 to 2024 (Sozialversicherungspflichtig Beschäftigte am Arbeitsort in ausgewählten Landkreisen Bayerns mit Wohnort Tschechien für die Jahre 2013 bis 2024). Special Analysis. 2025. Available from: https://www.destatis.de/DE/Themen/Arbeit/Arbeitsmarkt/Erwerbstaetigkeit/Tabellen/insgesamt.html (accessed on 2025 Feb 7).

[24] bayern innovativ Mobilität. Quarterly Report Q1 2025 Electromobility in Bavaria (Quartalsreport Q1.2025 Elektromobilität in Bayern). Bayern Innovativ GmbH; 2025 May. Available from: https://www.bayern-innovativ.de/en/emagazine/mobility/detail/quarterly-report-on-electromobility-in-bavaria-q1-2025 (accessed on 2025 Sept 25).

[25] European Commission. Record Month for BEV Registrations in Czechia in June 2024 | European Alternative Fuels Observatory. 2024. Source Data: Čistá Doprava website, Brno, Czechia. Available from: https://alternative-fuels-observatory.ec.europa.eu/general-information/news/record-month-bev-registrations-czechia-june-2024 (accessed on 2025 Sept 30).

[26] STARFOS. LUABA24085 – Analysis and optimization of the Czech-German commuting traffic to promote cross-border co-operation (Locomotion). 2024–2026. 2025. Available from: https://starfos.tacr.cz/en/projekty/LUABA24085 (accessed on 2025 Sept 30).

[27] Mayring P. Qualitative Inhaltsanalyse. Grundlagen und Techniken, 12th edn. Beltz Pädagogik. Beltz. Weinheim; 2015.

[28] Klöters M, Ooms W, Caniëls MCJ, Pijnenburg V. Transcending borders: conceptualising and empirically grasping individual readiness in cross-border collaboration in the Dutch–German borderland. Regional Studies. 2025;59(1):2522796. https://doi.org/10.1080/00343404.2025.2522796.

[29. Hou N, Shollock B, Petzoldt T, M'Hallah R. Qualitative insights into travel behavior change from using private cars to shared cars. International Journal of Sustainable Transportation. 2025;19(3):262–276. https://doi.org/10.1080/15568318.2025.2471773.

[30] Janíček P. The role of qualitative analysis in transport infrastructure planning. International Journal of Public Administration, Management, Economics and Development. 2020;5(1):16–25.

[31] Trager J, Jelínková M. Beyond economic incentives: role of personal networks in employing cross-border commuters. Journal of Borderlands Studies. 2025:1–24. https://doi.org/10.1080/08865655.2025.253911.

[32] Bavarian State Statistical Office (Bayerisches Landesamt für Statistik). Bayern kompakt 2024. 2024. Available from: https://www.statistik.bayern.de/mam/produkte/bayern_kompakt/bayern_kompakt_2024-deu.pdf (accessed on 2025 Sept 30).

[33] Cavallaro F, Dianin A. Cross-border commuting in Central Europe: features, trends and policies. Transport Policy. 2019;78:86–104. https://doi.org/10.1016/j.tranpol.2019.04.008.

[34] Karacan E. Mobility injustice and agency: confronting border asymmetries in cross-border commuting under COVID-19 re-bordering policies. Mobilities. 2025;1–16. https://doi.org/10.1080/17450101.2025.2498754.

[35] Kheng V, Pan L, Fan X. Human Capital:"Travel Broadens the Mind." MPRA Paper. 2025. Available from: https://mpra.ub.uni-muenchen.de/id/eprint/124156 (accessed on 2025 Aug 29).

[36] Edzes AJE, van Dijk J, Broersma L. Does cross-border commuting between EU countries reduce inequality? Applied Geography. 2022;139:102639. https://doi.org/10.1016/j.apgeog.2022.102639.

[37] Broersma L, Edzes A, Van Dijk J. Commuting between border regions in The Netherlands, Germany

and Belgium: an explanatory model. Journal of Borderlands Studies. 2022;37(3):551–573. https://doi.org/10.1080/08865655.2020.1810590.

[38] Eberhartinger E, Figari F, Fleischanderl H, Petutschnig M, Pistone P, Zagler M. Tax Barriers and Cross-Border Workers: Tackling the Fragmentation of the EU Tax Framework. Policy Department for Economy and Growth, Directorate-General for Economy, Transformation and Industry, European Parliament; Publications Office of the EU, Luxembourg, 2025 June. Report No.: PE 772.637. 2025. Available from: https://www.europarl.europa.eu/cmsdata/296344/Study%20Tax%20barriers%20and%20cross%20border%20workers.pdf (accessed on 2025 Oct 28).

[39] Zillmer S, Toptsidou M, Spule S. Analysis of Cross-border obstacles between EU Member States and Enlargement Countries. 2021. Publications Office of the EU, Luxembourg. https://doi.org/10.2776/164787. Available from: https://euro-ace.eu/sites/default/files/attached_documents/Analysis%20of%20cross-border%20obstacles%20between%20EU%20Member%20States%20and%20enlargement%20countries%20%20final%20report..pdf (accessed on 2025 Oct 31).

[40] Bertram D, Chilla T, Hippe S. Cross-border mobility: rail or road? Space-time-lines as an evidence base for policy debates. Journal of Borderlands Studies. 2024;39(5):913–930. https://doi.org/10.1080/08865655.2023.2249917.

[41] Getman AP, Yaroshenko OM, Tkachenko VS, Lutsenko OYe, Vapnyarchuk NM. Challenges to cross-border mobility of workers in the EU. AUC Geographica, 2025;9:e23361980. https://doi.org/10.14712/23361980.2025.9.

[42] Gaugitsch R, Gorny H, Dallhammer E, Mansutti S, Badouix M, Csizovszky A, et al. Cross-Border Regional Labour Market Analysis. Brussels: Directorate-General for Regional and Urban Policy, European Commission; Report No.: 1. Publications Office of the EU, Luxembourg, 2025. https://doi.org/10.2776/1527569.

[43] European Commission. Investment policy: Cohesion policy. 2020. Available from: https://ec.europa.eu/regional_policy/policy/what/investment-policy_en (accessed on 2025 Aug 29).

[44] Chilla T, Fráně L, Sielker F, Weber J. Cross-border regional development on the Bavarian-Czech border: The "right" forms of cooperation. Arbeitsberichte der ARL: Aufsätze, in: Chilla, Tobias & Sielker, Franziska (ed.), Cross-border spatial development in Bavaria: Dynamics in cooperation – Potentials of integration. ARL – Akademie für Raumentwicklung in der Leibniz-Gemeinschaft, Hanover. 2022;34:71–87.

[45] Chilla T, Kühne O, Neufeld M. Regional Development (Regionalentwicklung). Raumforschung und Raumordnung | Spatial Research and Planning. 2016;75(5):495–496. https://doi.org/10.1007/s13147-017-0497-9.