European cross-border accessibility by public transport: A methodological approach

Why do we need information on cross-border accessibility?

The permeability of cross-border regions in Europe has become a very important topic for the EU since the construction of the Schengen area in 1985 (European Commission: Directorate-General for Migration and Home Affairs 2015). Many initiatives and projects have been launched to ensure the accessibility of goods and services across borders within the Schengen Area and to facilitate seamless cross-border movement. For approximately 40% of the EU's total population living in border regions, cross-border mobility is essential for daily life to guarantee equal living conditions (Medeiros, 2019). Consequently, this topic is addressed by EU policy to foster a more cohesive Europe in terms of accessibility.

In some cases it is particularly beneficial to use services across the border for people living in close proximity to national borders because there might be a one-sided supply of services and goods due to populations density or demographic structure imbalances. Furthermore, there is huge demand for commuters to travel across borders (e.g. border regions to Luxembourg or Switzerland) and high frequency of cross-border public transport (CBPT) is needed. However, the accessibility for all citizens of border regions is especially limited in rural regions due to the absence of CBPT. Even where CBPT exists, it often lacks attractiveness due to complex multimodal chains, long travel times, and high fares (Cavallaro/Dianin 2020). Comparisons of travel times by train and car in Germany's border regions indicate that, in many cases, it is more beneficial for people to travel along but not across the border by train, even when accounting for traffic congestion (Bertram et al. 2024). Additionally, long-distance cross-border travel comparisons between rail and air have been conducted, often highlighting benefits for residents of larger cities rather than those in border regions (Brons et al., 2023). However, granular approaches focusing on service and goods accessibility in border regions remain limited to travel time analyses by car (e.g., Christodoulou & Christidis, 2019; Christodoulou et al., 2019) or case studies of CBPT, where researchers compare cross-border and domestic public transport (Cavallaro & Dianin, 2020; Vulevic et al., 2020) or train travel times (Poelman & Ackermans, 2017).

Recent studies on CBPT availability highlight a wide variation in services across European border regions. While some regions are well connected through multiple transport modes, others either lack services entirely or suffer from poor integration of cross-border bus and train lines with domestic

transport networks (EC, 2022). These disparities lead to differences in border region accessibility, resulting in varying travel times and opportunities for accessing services across borders. This particularly affects individuals unable to use private motorized transport, contradicting the goal of a cohesive Europe with equal opportunities for all citizens.

To enhance the knowledge base on CBPT services and the accessibility of goods and services for border region residents, granular travel time data is needed to inform better policies. Specifically, highly detailed multi-modal travel time analyses remain absent in accessibility research, making large-scale, evidence-based policymaking between border regions challenging. Our new methodological approach aims to address this gap by developing multi-modal travel time matrices across borders to assess access to essential services where better cross-border accessibility could improve life of citizens in border regions.

Data and methods

Generating granular accessibility data estimates for CBPT has not yet been a primary focus of transportation research. Attempts to comprehensively understand public transport accessibility for policy guidance are relatively new and often limited to case studies on specific towns and cities (Metz et al., 2024). The differences between subjective and objective accessibility can be substantial, as individuals shape their mobility environment based on personal experiences and knowledge. More extensive data collection is needed to develop calculated measures that policymakers can integrate with local and regional mobility insights to bridge the gap between perceived and actual mobility opportunities (Pot et al., 2021).

By utilizing a combination of OpenStreetMap (OSM), Google Transit Feeds (GTFS), and Point-of-Interest (POI) data, we demonstrate the feasibility of computing diverse multi-modal travel time matrices using the Rapid Realistic Routing on Multimodal Transport Networks (r5r) model by Pereira et al. (2019). We present an initial example of how to compute and compile accessibility data for border regions at a 1 km x 1 km grid cell level. Additionally, a key focus of our work is ensuring that this data is effectively communicated to its target audience, namely policy makers in border regions, so they can make informed decisions on where and how CBPT improvements can enhance equal living opportunities. To achieve this, we use Eurostat's (2025) data on basic services (education, health services) and OSM data on supermarkets as destination points, demonstrating the potential of our accessibility approach for policy formulation. Travel origins are represented by grid cell centroids, and various travel combinations, including walking and public transport, biking and public transport, and e-bike and public transport, will be assessed. Finally, travel time matrices will be used to create

interactive dashboards, maximizing the usability and flexibility of the data. There are many challenges while collecting these data as well as how to process huge amounts of travel time matrices.

Results and conclusion

Utilizing existing cross-border services is often hindered by mental, physical and especially administrative barriers as well as a lack of awareness (e.g., public health services—Bruthans & Jiráková, 2023; airports—Zijlstra, 2020). Through our data-driven approach, which calculates multi-modal travel times for CBPT access to services and goods, we aim to provide policy makers in border regions with valuable insights. This data enables an understanding of how many people currently benefit from existing CBPT solutions and how many more could benefit if better transport options were available.

Creating comparable data for border regions is crucial for developing strategies that transcend individual case studies (Tsiopa et al., 2024: 905). By incorporating real-world data from OSM, GTFS, and POI sources, it becomes easier to identify CBPT bottlenecks, pinpoint areas where CBPT should be improved to access essential services, and highlight existing best practices in cross-border transport. Many physical barriers persist, such as inadequate border-crossing infrastructure (e.g., bridges), unconnected public transport networks, and poorly integrated road systems in border regions (Medeiros, 2019). More extensive data collection, particularly in the form of customizable visualizations, will enhance evidence-based policymaking for CBPT and enable the assessment of programs and projects aimed at improving cross-border public transport across Europe.

Finally, a critical discussion about potential for the data collection process and future research trajectories are finalized in the draft version of the paper. The reason why accessibility on CBPT has been neglected is strongly related with limited technical capabilites in the past. We show how a tool which was designed for an urban policy context can be used in a cross-border dimension to improve the knowledge base about CPBT in the future.

Literature

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