URBAN-RURAL DIGITAL DIVIDES IN VISEGRAD COUNTRIES

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Abstract

Digitalisation has a profound influence on regional development, yet disparities in digital access and usage persist across the Visegrad countries. This study examines the digital divide in urban, suburban, and rural areas and considers access to broadband, digital skills, and online activities. The results reveal significant disparities in digital development levels between different areas. The analysis also reveals that geographic and socioeconomic factors significantly influence the extent of digital inequality across regions. These findings emphasise the importance of considering intra-national regional variations within the context of broader digital transformation processes. By providing a detailed, data-driven perspective, this research contributes to a more nuanced understanding of regional digital disparities within the Visegrad countries and offers a foundation for future research and discussion on regional stability and development in the context of increasing digital integration.

Keywords: Urban-Rural Digital Divide, Digitalisation, Composite Index, Regional Development

Introduction

In recent years, digitalisation has become a key topic in discussions about economic growth, social inclusion, and regional development (Binder and Witting, 2022; Cruz-Jesus *et al.*, 2012; De Clercq *et al.*, 2023; Lindberg *et al.*, 2024). As nations strive to capitalise on the transformative potential of digital technologies, significant disparities in digital access, usage, and ability to reap the benefits of digitalisation have become apparent (Cruz-Jesus *et al.*, 2012; De Clercq *et al.*, 2023; Lindberg *et al.*, 2024), particularly between different geographical regions and demographic groups. This phenomenon is commonly referred to as the urban–rural digital divide and encompasses differences in access to broadband and digital infrastructure, as well as disparities in digital skills, online engagement, and the capacity to derive socio-economic benefits from digital tools.

The Visegrad countries (comprising Poland, the Czech Republic, Slovakia, and Hungary) exemplify this challenge, with marked contrasts in the digital landscape between urban, suburban, and rural environments. While urban areas tend to benefit more extensively from digitalisation (Balogun *et al.*, 2020; Feurich *et al.*, 2023; Pelucha and Kasabov, 2019) due to better infrastructure, higher digital literacy, and more diverse economic opportunities, rural regions (especially peripheral ones) often lag behind (Li *et al.*, 2019; Pontones-Rosa *et al.*, 2021). These areas face structural disadvantages such as population decline due to selective migration and an ageing population, as well as limited public and private investment (Feurich *et al.*, 2023; Kouřilová *et al.*, 2024; Pelucha and Kasabov, 2019). These factors contribute to digital exclusion and broader socio-economic stagnation (De Clercq *et al.*, 2023).

A significant contribution of this study is its inclusion of suburban areas in the analysis. This approach moves beyond the traditional urban–rural dichotomy to reflect the reality of mass suburbanisation, which has reshaped regional settlement patterns in recent decades. According to Li *et al.* (2019), suburban zones often occupy an ambiguous position in terms of digital development: while they benefit from proximity to urban centres, they also face infrastructural and demographic challenges that distinguish them from urban cores and rural hinterlands.

The concept of the digital divide is central to this study. It is defined as the discrepancy between individuals who have access to contemporary information and communication technology and those who do not. This divide encompasses more than just technological availability; it also includes socioeconomic factors that influence the ability to leverage digital tools effectively. As Vassilakopoulou and Hustad (2023) have argued, inequitable access to digital resources has indeed become a significant barrier to sustainable societal progress. As this study progresses, it becomes clear that digital accessibility is closely linked to geographical, economic, and demographic factors that significantly impact regional disparities (Billon *et al.*, 2009; Lucendo-Monedero *et al.*, 2019; Ruiz-Rodríguez *et al.*, 2018).

Furthermore, as the digital economy grows, it simultaneously increases its ability to reshape urban–rural dynamics. Li *et al.* (2019) emphasise how digital technologies facilitate the integration of urban and rural areas by reconfiguring traditional economic structures and optimising resource allocation. However, this integration is not without challenges; the urban-centric manifestation of digital technologies often marginalises rural communities, exacerbating existing disparities (Cowie *et al.*, 2020; Ferrari *et al.*, 2022).

This study therefore seeks to answer the following central research question: How do urban, suburban, and rural areas in the Visegrad countries differ in terms of access to and usage of digital technologies, and digital skills? Addressing this question highlights structural inequalities and the necessity of deliberate, data-driven policies to bridge these divides. In particular, the study emphasises the importance of implementing strategies sensitive to the specific needs of rural regions, such as the application of the rural proofing concept to ensure national policies are evaluated for their impact on rural communities. Only through such targeted, inclusive approaches can digitalisation serve as a genuine driver of regional cohesion and sustainable development.

Literature Review

Conceptualising the Digital Divide: Beyond Access

Over the past two decades, the concept of the digital divide has evolved significantly. It has transitioned from a narrow focus on technological access to a multidimensional framework encompassing usage, digital literacy, and the ability to derive meaningful benefits from digital technologies (Feurich *et al.*, 2023; Reveiu *et al.*, 2023; Vasilescu *et al.*, 2020). Traditionally, the digital divide referred to disparities in access to information and communication technologies among individuals or regions. However, contemporary scholarship increasingly emphasises that access alone is insufficient to ensure digital inclusion (Chetty *et al.*, 2018; Ferrari *et al.*, 2022; Vasilescu *et al.*, 2020). The effective utilisation of ICTs and the capacity to translate digital engagement into tangible socio-economic outcomes are now recognised as equally critical dimensions (Ferrari *et al.*, 2022; Feurich *et al.*, 2023; Kouřilová *et al.*, 2024; Pelucha and Kasabov, 2019).

In the context of regional development, the digital divide is most evident in spatial disparities, particularly between urban and rural areas (De Clercq *et al.*, 2023; Giannakis and Bruggeman, 2020; Konjar *et al.*, 2018). Urban regions typically have superior digital infrastructure, higher levels of digital literacy, and greater integration of digital services into everyday life. In contrast, rural areas often suffer from infrastructural deficits, limited service provision, and demographic challenges such as ageing populations and selective outmigration (Ferrari *et al.*, 2022; Pelucha and Kasabov, 2019). These disparities are not merely technological; they have profound implications for social cohesion, quality of life, and territorial stability. Regions experiencing selective migration, whereby younger and more educated individuals relocate (Pontones-Rosa *et al.*, 2021) to urban centres, face the dual challenges of a shrinking and ageing population and declining economic vitality (Cowie *et al.*, 2020; Kouřilová *et al.*, 2024; Li *et al.*, 2019). Digital exclusion in such contexts can exacerbate existing vulnerabilities and contribute to long-term regional decline.

Nevertheless, digitalisation offers rural and peripheral regions the chance to bypass traditional development trajectories (Capello and Cerisola, 2021; Feurich *et al.*, 2023; Li *et al.*, 2019). The growth of remote working, e-government services, online education, and digital entrepreneurship provides new opportunities for socio-economic revitalisation (Ferrari *et al.*, 2022; Lindberg *et al.*, 2024; Reveiu *et al.*, 2023). If utilised effectively, digital technologies can mitigate geographic isolation, improve service delivery, and promote inclusive growth. Nevertheless, this window of opportunity is limited. Without targeted interventions and strategic planning, rural areas risk being permanently left behind in the digital transition compared to urban areas (Cowie *et al.*, 2020).

It is important to note that the urban–rural dichotomy often oversimplifies the spatial dynamics of digital inequality (Konjar *et al.*, 2018). Suburban areas have expanded rapidly in recent decades due to mass suburbanisation, occupying a zone between urban centres and rural areas. These regions often experience infrastructural strain, fragmented governance, and inconsistent service provision. However, they are rarely the focus of digital policy frameworks, which tend to prioritise either densely populated urban centres or structurally disadvantaged rural areas (Li *et al.*, 2019). Therefore, to gain a comprehensive understanding of the digital divide, it is essential to recognise the distinct characteristics and needs of suburban territories.

In summary, the digital divide is a multifaceted phenomenon that intersects with the economic, social, and demographic dimensions of regional development. Addressing it requires moving beyond simplistic metrics of access and embracing a holistic approach that considers usage patterns, benefit realisation, and the broader territorial context. Only through such an integrated perspective can digitalisation serve as a catalyst for equitable and sustainable regional development.

Measuring Digitalisation: Challenges and Approaches

Despite the role of digitalisation as a catalyst for regional development, its uneven spatial diffusion continues to exacerbate existing territorial disparities. In order to comprehend and address these disparities, there is a necessity for the utilisation of robust, data-driven instruments (Bryce, 2025; Pelucha and Kasabov, 2019; Pontones-Rosa *et al.*, 2021) capable of capturing the intricacies of digital transformation across diverse geographical regions. However, the measurement of digitalisation is challenging (Bruno *et al.*, 2011, 2023; Chetty *et al.*, 2018; Lucendo-Monedero *et al.*, 2019) due to its multidimensional nature, encompassing infrastructure, skills, usage, and the capacity to benefit from digital technologies.

In recent decades, a number of composite indices have been developed for the purpose of monitoring digital progress (Benecchi *et al.*, 2023; Bruno *et al.*, 2023; Thordsen *et al.*, 2020). The most notable of these is the Digital Economy and Society Index (DESI), which was introduced by the European Commission (2023). The DESI framework employs a multifaceted approach to assess digital performance, encompassing four core dimensions: connectivity, human capital, internet service utilisation, and digital public services. It plays a pivotal role in shaping EU digital policy and evaluating progress across member states. However, it should be noted that the programme operates exclusively at the national level (Bruno *et al.*, 2023; Thordsen *et al.*, 2020) and does not take into account disparities within countries, particularly between urban, suburban, and rural areas.

The OECD (2022) Digital Transformation Indicators, initiated in 2019 as part of the Measuring the Digital Transformation initiative, are designed to evaluate the comprehensive economic and societal ramifications of digitalisation. These indicators, which span domains such as education, innovation, and well-being, are designed to support policy development in OECD countries. While the framework is conceptually comprehensive, it lacks territorial disaggregation and is not tailored to analyse spatial inequalities.

The E-Government Development Index has been overseen by the United Nations since 2003. The index serves as a metric for evaluating national governments' capacity to deliver digital public services. The report combines data on online services, telecommunications infrastructure, and human capital. The EGDI is a valuable tool for the assessment of digital governance; however, it does not take into account the presence of regional variation within countries (Thordsen *et al.*, 2020).

While these indices offer valuable insights into national-level digitalisation, they fail to capture the territorial dimension of digital inequality. A number of endeavours have been undertaken in an attempt to address this discrepancy. For instance, Benecchi *et al.* (2023), Bruno *et al.* (2023), Lucendo-Monedero *et al.* (2019), and Ruiz-Rodríguez *et al.* (2018) developed regional digitalisation indices. This development marks a significant step forward in the realm of spatially sensitive measurement. However, the regions employed in the analysis (predominantly NUTS2) persist in demonstrating internal heterogeneity, thereby limiting the capacity for comprehensive analysis of urban, suburban, and rural dynamics.

Despite extensive research in this area, a comprehensive index capable of systematically measuring the digital divide between urban and rural regions throughout Europe remains to be established. Existing tools have limited capacity to address this issue, as they either aggregate data at the national level (or at the NUTS2 regional level) or focus only on a specific area of digitalisation (ICT use in households, ICT in businesses, etc.). This issue is made worse by two related trends. Firstly, there is suburbanisation, and secondly, there is the demographic decline of rural areas on the edge of the country. In these areas, digital exclusion meets broader socio-economic vulnerabilities (Kouřilová *et al.*, 2024; Lindberg *et al.*, 2024; Pelucha and Kasabov, 2019).

The present study addresses this issue by introducing a composite index that measures digital inequality and integrates four thematic domains: internet access, digital public services, digital skills, and individual internet usage. The index is notable for its implementation of Eurostat's harmonised classification of urbanisation (Eurostat, 2024b), a methodological framework that aims to standardise the measurement of urbanisation across diverse geographical and temporal scales. This approach facilitates a more detailed, policy-relevant evaluation of digital disparities across urban, suburban, and rural regions, thereby offering a more nuanced understanding of regional digital inequality in the Visegrad countries.

Methodology

The present study employs a composite indicator approach to evaluate digital inequality in urban, suburban, and rural areas across the European Union. Although the methodology was developed for all EU member states, this paper focuses specifically on the Visegrad countries in order to provide a regional analysis.

The composite index is constructed from four thematic domains: internet access, digital public services, digital skills, and individual internet usage. The selection of indicators was informed by a set of criteria encompassing relevance, availability, and alignment with EU digital policy frameworks. The data presented were sourced from Eurostat's ICT usage surveys (Eurostat, 2024a) and were subsequently disaggregated by degree of urbanisation (Eurostat, 2024b).

The categorisation of territorial units was undertaken in accordance with the Eurostat methodology (Eurostat, 2024b) for the harmonised classification of urbanisation degrees. The methodology employed in this study classifies Local Administrative Units into three distinct categories:

• urban areas, which comprise cities,
• suburban areas, which consist of towns and suburbs, and
• rural areas.

The classification is based on population density and spatial contiguity, using 1 km² population grid data (Eurostat, 2024b). In order to ensure the comparability of the indicators across different countries and territorial types, they were normalised. To achieve this objective, the min–max method was utilised to transform each value onto a scale from 0 to 1, employing the following formula:

$$x'_{ijk} = \frac{(x_{ijk} - \min x_{ijk})}{(\max x_{ijk} - \min x_{ijk})}.$$

The composite indicator is calculated as the arithmetic mean of all normalised indicators. In instances where the significance of the indicators varies, a weighted version is employed. To quantify digital disparities between territorial types, absolute and relative gaps are calculated. The estimation of the contribution of individual indicators to overall digital inequality is achieved through the utilisation of OLS regression models. The models under scrutiny compare digital disparities between urban, suburban, and rural areas. The following example model specifications are provided for reference:

• The first model to be considered is that of cities versus suburbs.
• The second model contrasts urban and rural areas.
• The third model contrasts suburban and rural areas.

The higher the number of indices, the wider the urban-rural digital gap.

Results

Investigating digital inequality across the European Union (EU) member states reveals significant geographical variations in digital access and utilisation. However, the next section focuses on the Visegrad countries, which offer a nuanced perspective on digital inequality shaped by shared historical legacies and differentiated post-accession trajectories.

Regional Digital Disparities in the Visegrad Countries

Although the Visegrad countries share a common post-socialist legacy and synchronous EU accession, they exhibit notable differences in socioeconomic development, infrastructural capacity, and settlement structures (Rezabek *et al.*, 2022; Schwarcz *et al.*, 2021) that shape their digitalisation trajectories. These structural characteristics directly impact the spatial distribution of digital infrastructure and skills, as well as a region's capacity to benefit from digital transformation.

During the socialist period, infrastructure development in the V4 countries was highly centralised, with investments concentrated in industrial urban centres (Schwarcz *et al.*, 2021). Peripheral and rural regions were systematically underfunded, resulting in long-standing disparities in physical connectivity and service provision (Rezabek *et al.*, 2022; Schwarcz *et al.*, 2021). This legacy continues to influence the uneven rollout of digital infrastructure, particularly in rural areas.

Following EU accession in 2004, all four countries gained access to structural and cohesion funds aimed at modernising infrastructure and promoting digitalisation. However, their ability to effectively utilise EU funds, known as absorptive capacity, has varied (Rezabek *et al.*, 2022; Schwarcz *et al.*, 2021). Czechia and Slovakia, for example, have demonstrated relatively strong institutional frameworks and administrative capacity, enabling them to implement digital infrastructure projects more consistently. In contrast, Hungary has faced challenges related to fragmented governance and centralised decision-making, which have limited the scope and effectiveness of digital investments (Rezabek *et al.*, 2022).

The Czech Republic and Slovakia demonstrate a more equitable distribution of regional development (Rezabek *et al.*, 2022), characterised by comparatively diminished levels of income inequality and enhanced public service delivery in non-metropolitan regions. In particular, the Czech Republic has made notable progress in the areas of digital skills and civic digital inclusion, supported by targeted national strategies and EU co-financing (European Commission, 2024). Slovakia has also made significant progress in the realm of digital education and infrastructure, though rural areas continue to face challenges. Hungary and Poland, by contrast, display more pronounced regional disparities. In Hungary, efforts to digitalise are focused in Budapest and a small number of other urban areas, while rural regions are lagging behind in terms of both infrastructure and digital literacy. Poland faces similar challenges (Kolisnichenko, 2025).

Since the 1990s, all four countries have experienced significant suburbanisation, driven by housing market dynamics, the decentralisation of services, and lifestyle preferences. It is evident that suburban zones, which are often located in commuter belts, frequently suffer from infrastructural strain, fragmented service provision, and ambiguous administrative status. Despite their growing demographic and economic significance, these areas are rarely addressed in digital policy frameworks.

Consequently, suburban regions are considered a significant gap in digital policy design. The fact that they are in close proximity to urban centres does not ensure the presence of adequate digital infrastructure or effective service delivery, and their exclusion from both rural and urban classifications hinders the implementation of targeted intervention strategies.

Urban-Rural Digital Divide in V4 Counties

This section presents the core findings of the analysis on territorial digital inequality across the Visegrad countries. The study utilises a composite indicator to measure disparities in digital access and infrastructure, with a focus on the differences between urban, suburban, and rural areas within each country.

The initial section of the analysis focuses on absolute digital inequality, which refers to the overall level of disparity in digital access and infrastructure across territorial units within each nation. This measure captures the extent to which digital resources, including but not limited to broadband connectivity, access to online services, and digital skills, are distributed unevenly across urban, suburban, and rural areas. Higher values indicate more pronounced territorial imbalances, while lower values suggest a more equitable distribution.

The findings indicate that Poland and Hungary demonstrate the highest levels of absolute inequality, while the Czech Republic and Slovakia exhibit comparatively lower, though still significant, disparities.

Poland (0.674) and Hungary (0.631): both countries exhibit significant disparities between urban and rural regions. These disparities are exacerbated by urban-centric infrastructure planning and the limited reach of digital literacy programmes in peripheral regions.

Czechia (0.531) and Slovakia (0.510): these countries have clearly achieved more consistent progress in deploying digital infrastructure. However, suburban areas, particularly commuter belts and peri-urban zones, continue to experience infrastructural strain and fragmented service delivery.

A comparative analysis of territorial digital inequality in Poland, Hungary, the Czech Republic, and Slovakia reveals significant variations in the scale and composition of the digital divide within each
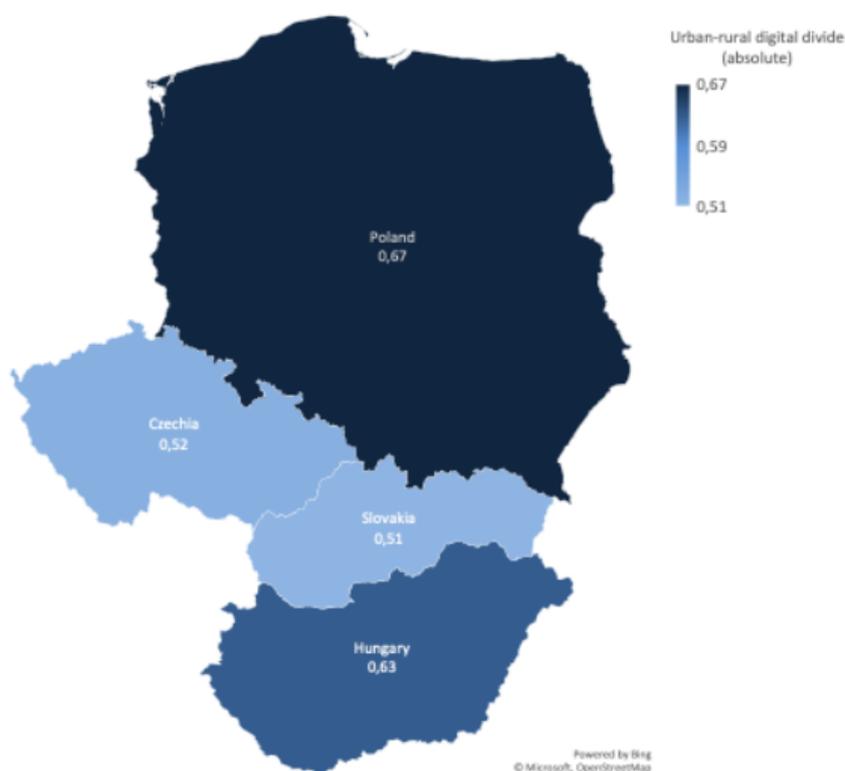
1: Digital divide in V4 countries
Source: own elaboration based on data from Eurostat (2024)
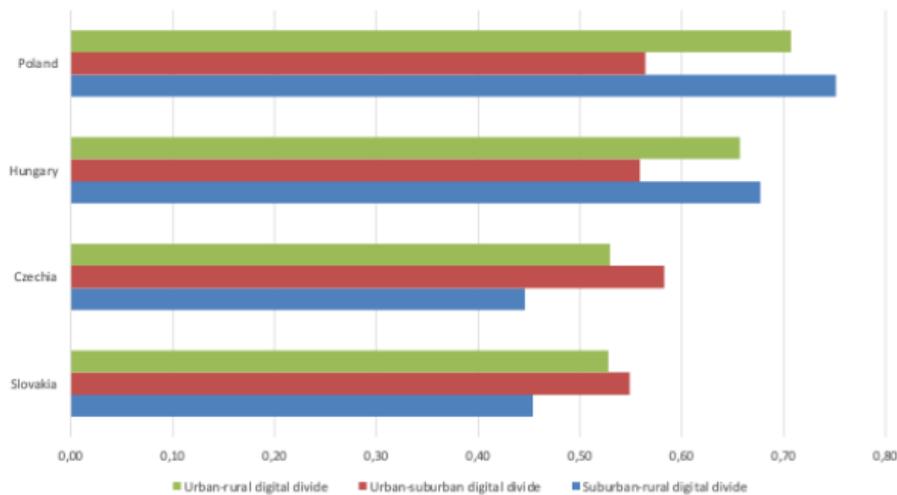
2: Inner structure of the digital divide (V4 countries)
Source: own elaboration based on data from Eurostat (2024)

country. In Poland and Hungary, where the composite indicator values are highest, the most significant disparities are evident between suburban and rural areas. This suggests that rural regions are structurally disadvantaged even compared to suburban areas that are closer to urban centres. While suburban areas may benefit from partial spillover effects of urban infrastructure, the data indicate that rural communities continue to face significant barriers in accessing digital services and connectivity.

Notably, the distinction between urban and suburban regions in these two countries is relatively subtle, suggesting an incremental dissemination of digital infrastructure from urban centres to outlying areas. This gradient reflects a tiered spatial structure, whereby digital access decreases with increasing distance from urban centres, albeit not uniformly. The contrast between suburban and rural areas is striking, indicating a threshold beyond which infrastructural investment and service provision decrease more rapidly.

In contrast, although Czechia and Slovakia exhibit lower overall levels of inequality, their internal structures reveal different challenges. Despite the less pronounced disparities between urban and rural areas, both countries have significant disparities between urban and suburban zones. This suggests that, despite being presumed to be well connected due to their proximity to cities, suburban areas may occupy a transitional space where digital infrastructure is unevenly developed and administrative support is fragmented. These findings emphasise the necessity of examining the specific dynamics that shape digital access across different spatial contexts and disaggregating territorial categories.

Discussion and Conclusion

This study offers a nuanced view of territorial digital inequality in the Visegrad countries, broadening the analytical focus beyond the conventional urban–rural divide to encompass suburban areas as a distinct spatial category. This approach has the capacity to reveal important structural nuances that are often overlooked in conventional analyses. The findings show that digital disparities are not just a matter of urban versus rural access (Cowie *et al.*, 2020; De Clercq *et al.*, 2023; Ferrari *et al.*, 2022); they are also shaped by more complex territorial gradients. The most pronounced disparities are observed between suburban and rural areas in Poland and Hungary, indicating that rural regions remain significantly disadvantaged. By contrast, the Czech Republic and Slovakia demonstrate a more balanced urban–rural dynamic. However, these countries still face challenges in suburban areas.

Incorporating suburban areas into the analysis provides a clearer picture of how digital inequality manifests itself in different locations. The idea that these areas benefit from proximity to urban areas is not supported by evidence. In fact, these regions have been demonstrated to be transitional zones. This tripartite territorial framework, comprising urban, suburban, and rural areas, provides a more accurate and policy-relevant picture of digital exclusion.

The findings also highlight the limitations of national aggregate indicators (such as DESI, European Commission, 2024), which fail to capture disparities within countries. Despite moderate national performance, all four countries exhibit significant internal inequalities, which are obscured by top-level metrics. This emphasises the need for indicators and digital strategies that are disaggregated by territory and spatially sensitive in order to reflect the lived realities of structurally disadvantaged regions.

It is recommended that future research builds on this territorial differentiation by examining how digital inequalities evolve over time, particularly in response to policy interventions and infrastructural investments. Longitudinal studies could help to establish whether suburban areas are converging with urban standards or diverging further from them. Furthermore, qualitative research is needed to explore the lived experiences of digital exclusion in suburban and peri-urban areas, where administrative boundaries and service provision interact in complex ways. Analysing such data would improve our understanding of infrastructural diffusion and help identify areas with the most limited digital access. This would further refine our theoretical understanding of the spatial dynamics of digital inequality. Moreover, it would inform the development of more targeted and effective policy responses.

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