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Which Regions Gain the Most From Digital Transition: Urban, Suburban, or Rural?

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Abstract

Since the outbreak of Covid-19, the digital transition has intensified globally. This study examines its spatial dynamics by focusing on the distribution of fast internet across settlements and how it relates to the location of IT companies and the residential patterns of IT workers. While existing research often emphasizes the urban–rural divide, we go beyond this by adopting a full-country approach at a fine spatial scale and by distinguishing between urban, suburban, and rural contexts. The study focuses on Estonia, a digitally advanced country known for its e-governance and digital public services. Using multiple data sources—including fast internet availability, business registry data to map IT company locations, and individual-level census microdata to trace the residences of IT workers—we conduct a detailed spatial analysis at the settlement level. Our findings show that telecom companies provide fast internet primarily in urban areas, while public subsidies have aimed to address market failures in less urbanized regions. Areas with fast internet host nearly four times as many IT companies and three to four times as many IT workers as unconnected regions. IT companies are highly concentrated in Estonia's two main cities, while IT workers are more dispersed, extending into suburban and exurban areas. Settlements with fast internet and higher shares of IT workers also report significantly higher income levels. The Estonian case highlights the importance of targeted public policy to address the cumulative and spatially uneven effects of digital transition. Expanding fast internet access to underserved regions is essential for inclusive and balanced regional development.

Keywords

digital transition; high-speed internet infrastructure; IT companies; IT workers; regional divides

1. Introduction

Growing regional divides between economically vibrant cities and peripheral areas have become a defining challenge of regional development. While large cities thrive—attracting capital, talent, and innovation—many rural areas face stagnation or decline (Rodríguez-Pose et al., 2024). Cities serve as magnets for businesses and people, hosting universities, generating knowledge spillovers, and functioning as hubs of global networking and innovation (Bathelt et al., 2024). The divide between major cities and peripheral areas is deepening (Rodríguez-Pose, 2018).

Digital transition—the integration of digital technologies into the economy and society—has emerged as a potential game-changer in redefining regional divides (European Commission, 2022). Accelerated by the Covid-19 pandemic, the shift from physical to digital space has transformed how people and places connect to opportunities (Lythreatis et al., 2022). The interplay between centralizing and decentralizing forces lies at the heart of debates on spatial consequences (Fu et al., 2024). Two trajectories are emerging: one deepening existing divides, another reducing them.

Cumulative advantage explains how regional inequalities reinforce over time. The "Matthew effect" (Merton, 1968) describes how initial advantages accumulate, further benefiting prosperous areas. Major cities attract talent and strengthen their role as control centers of the world economy (Sassen, 1991), with digital tools potentially consolidating this dominance. Fielding's escalator regions concept (Fielding, 1989, 1992) highlights how certain areas offer enhanced opportunities that draw skilled labor and facilitate upward mobility.

In contrast, Hägerstrand's (1967) contagious diffusion concept suggests innovations spread outward from urban centers, extending opportunities beyond major cities. Moss (1987) argued that while telecommunications facilitate business clustering in large cities, rural areas could benefit from remote work and digital businesses with appropriate infrastructure and policies. The IT sector has become one of the fastest-growing parts of modern economies. The spatial distribution of IT companies and their workforce is strongly influenced by digital infrastructure availability (van Dijk, 2020). By driving innovation and productivity, the IT sector can serve as both an indicator and a catalyst for both more balanced regional (Zālīte et al., 2025) and urban (Tammaru et al., 2021) development.

Despite growing recognition of digital infrastructure as critical for regional development, knowledge gaps remain in understanding how it influences regional change (Bathelt et al., 2024). This study examines whether digital transition reinforces existing regional inequalities or creates new opportunities by analyzing the interplay between digital infrastructure availability, IT company locations, and IT worker residential choices. We go beyond the urban–rural dichotomy to understand how the digital transition affects different settlement types—urban, suburban, and rural. More specifically, our analysis seeks to answer three interrelated research questions:

1. Does the location of digital infrastructure, specifically fast internet, follow existing regional divides?
2. How does the availability of fast internet relate to the spatial distribution of companies, particularly those in the IT sector, relative to other companies?
3. How does the availability of fast internet correlate with the residential distribution of IT sector employees compared to employees in other sectors?

This study focuses on Estonia, a country with a market-driven economy and limited regional policy interventions (Raagmaa, 2023). Its digital infrastructure development combines market-driven investments with public initiatives: Private telecommunication companies target profitable urban and suburban areas, while the state focuses on peripheral and rural regions. This dual approach creates a complex spatial landscape where high-speed internet access is shaped by both market forces and public interventions. Public investment has proven effective in narrowing urban–rural digital divides (Briglauer et al., 2019). This article analyzes digital transition's spatial footprint in this market-based context, examining how effects manifest across the settlement system.

The article proceeds as follows: The next section presents the conceptual framework for understanding how digital infrastructure relates to regional divides, followed by a literature review synthesizing key empirical findings. The data and methods section outlines sources and analytical techniques. The results section examines the spatial clustering of IT companies, IT workers, and income distribution across areas with varying digital infrastructure. The discussion interprets findings through the lens of spatial divides and regional inequalities. The article concludes by summarizing key findings and outlining directions for future research.

2. Conceptual Approach: Effects of Digital Transition in Urban, Suburban, and Rural Areas

Urbanization, suburbanization, and counterurbanization have long shaped regional development (van den Berg et al., 1982). Digital technologies now transcend physical boundaries, reshaping where people can live and work and blurring lines between urban, suburban, and rural areas. The Covid-19 pandemic accelerated this transformation, bringing remote work and online services into everyday life across the settlement system (Ciccarelli & Mariotti, 2024; Oleaga, 2025). However, little is known about how these shifts redistribute opportunities—including employment access, flexible work arrangements, and housing options—across different spatial contexts. In this section, we propose a conceptual framework for understanding how the digital transition is driving change across urban, suburban, and rural contexts (Figure 1).

Following our conceptual framework, we focus on how the digital transition affects urban, suburban, and rural areas through labor and housing market changes. The digital transition affects labor market change in two key ways. First, it enables automation and information economy expansion, which increases demand for highly skilled workers in sectors like IT (Hamnett, 2024). Second, remote and hybrid work arrangements have become mainstream among professionals, decoupling work from physical proximity to employers. This gives workers greater flexibility in residential location based on lifestyle preferences, family needs, or housing affordability.

Growing professionalization and work flexibility are reshaping housing markets. As professionals cluster in major cities, housing demand and prices rise, displacing lower-income groups (Van Ham et al., 2021) and pushing even some professionals beyond core employment areas (Ramani et al., 2024). Digital transition has accelerated housing financialization through online real estate platforms and short-term rental services (Cocola-Gant et al., 2021). These tools enable local and international investors to easily buy, manage, and monetize housing. Apartments in high-demand urban and touristic locations increasingly serve as investment assets rather than homes for long-term residents (Barron et al., 2019; Pettas et al., 2024).

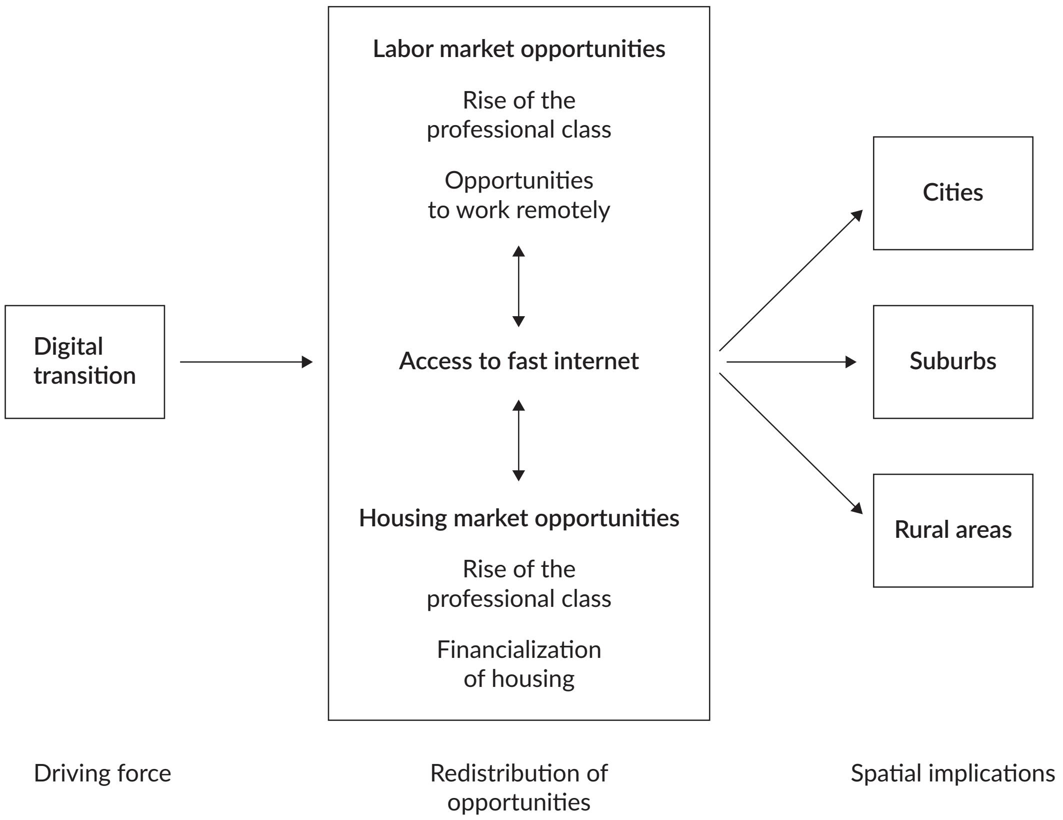

Figure 1. Digital transition as a driver of urban, suburban, and rural change.

High-speed internet drives change across work and housing domains. By enabling remote work and transforming housing markets, digital connectivity reshapes the context in which people decide where to live and businesses where to operate. Large cities continue attracting investment, skilled workers, and high-paying jobs, reinforcing their economic dominance (Althoff et al., 2022; Luca et al., 2025). Simultaneously, rising prices displace long-term residents (Wolf & Irwin, 2024), unlocking opportunities for digitally connected non-metropolitan areas as destinations for remote workers and lifestyle migrants seeking affordability and quality of life (Malecki, 2003; Mießner & Naumann, 2024). In some cases, this rural gentrification helps reverse population decline by bringing capital, skills, and new economic activity (Bogason et al., 2024).

Our approach goes beyond the urban–rural binary by explicitly incorporating suburban areas, which are becoming ideal grounds for the opportunities arising from the digital transition. Suburban areas are increasingly seen as compromise locations for high-skill workers seeking both proximity to urban job markets and improved housing affordability or quality of life. With better internet access than rural areas, suburbs support remote work and family needs, enabling a shift from central cities to more spacious, affordable suburban living—even as companies and IT jobs remain city-centered (McArthur & Hong, 2023; Tan et al., 2023).

While digital transition may deepen regional divides by concentrating employers in central areas, it also holds potential to bridge divides through residential decisions. Rising housing costs push residents outward, while remote work makes suburban and rural living feasible. Fast internet investments enhance appeal of non-metropolitan areas, enabling smaller businesses to reach broader markets, create jobs, and attract skilled workers (Deller et al., 2022; Fu et al., 2024). Even where local job markets remain limited, improved connectivity supports remote employment and digital inclusion (Ciccarelli & Mariotti, 2024; Li et al., 2024; Peng & Dan, 2023). However, unequal access to digital technologies—the digital divide—remains a pressing social justice issue. Digital exclusion exacerbates marginalization among vulnerable populations, making equitable connectivity investments critical for inclusive regional development (Ragnedda et al., 2022; van Dijk, 2020).

3. Digital Transition and Spatial Inequality: Existing Evidence and Knowledge Gaps

The digital transition is transforming spatial development patterns through multiple channels, such as improved access to digital infrastructure, expanded opportunities for remote work, and the consequent shifts in residential location choices (Hostettler Macias et al., 2022). Research reveals pronounced concentration of IT sector employees and companies in major cities, reinforcing existing regional divides and supporting the escalator region concept (Ali et al., 2019; Keuschnigg et al., 2019). However, patterns vary: While some cities concentrate IT workers in urban cores, others show more dispersed distributions (Bauer, 2018; Foley et al., 2022). At the local scale, significant intra-city disparities emerge, with tech workers clustering in well-connected and attractive neighborhoods, amplifying gentrification (Foley et al., 2022; Francis & Weller, 2022; Zālīte et al., 2025). Tech-related activities remain concentrated in and around urban centers (Gallardo et al., 2021), deepening the metropolitan-non-metropolitan divide.

The adoption and use of digital services does not, thus, take place at the same pace in urban and rural environments, with rural areas lagging behind (Gallardo et al., 2021; Lengyel et al., 2020; Rodríguez-Pose, 2018). Nevertheless, Fu et al. (2024) demonstrate that rural areas may benefit from the digital transition, too, as innovations spill over from large cities to other regions. For instance, Deller et al. (2022) found a positive association between increased startup activity in IT-related sectors and higher access to fast internet in rural USA counties, suggesting that digital transition can support the decentralization of IT sector companies and employees if the infrastructure enables it. Other studies further suggest that tailored digital development strategies can help mitigate existing disparities and empower rural areas, even when initial inequalities are pronounced (Fu et al., 2024; Rodríguez-Pose, 2018).

According to McArthur and Hong (2023), residing in areas with fast internet leads to increased remote work, suggesting that digital infrastructure plays an important role in enabling its adoption. Hostettler Macias et al. (2022) further link this trend to shifts in the residential redistribution of workers toward both rural and suburban areas. Covid-19 sparked counter-urbanization patterns, with migration toward holiday villages, peri-urban coastal areas, and some remote regions (Argent & Plummer, 2024; González-Leonardo et al., 2022). However, debate persists over whether these patterns reflect genuine counter-urbanization or merely extended suburban sprawl into metropolitan hinterlands (Denham, 2021), and whether they represent only a short-term response to the health crisis or a more structural shift enabled by new opportunities to decouple home and work brought about by the digital transition. The spatial character of these movements remains uncertain, too, with some scholars pointing to extended suburbanization rather than genuine counter-urbanization to more remote rural settlements (González-Leonardo et al., 2022), labelled as a “donut effect” by Ramani and Bloom (2021). Emerging research highlights that suburbs may, indeed, be the long-term key beneficiaries of digital transition (Hostettler Macias et al., 2022). Hybrid work arrangements enable workers to live further from workplaces while maintaining periodic commuting, limiting relocation to distant rural areas, and instead driving suburbanization and urban sprawl (Ramani et al., 2024; Tan et al., 2023).

While research increasingly examines digital transition's spatial impacts, most studies focus on urban–rural divides, largely overlooking suburbs as distinct and dynamically changing spaces. Moreover, infrastructure distribution, company location, and worker residence are rarely analyzed together, and the role of public investment in mitigating market-driven inequalities in developing digital infrastructure. This study contributes to addressing these gaps by examining how the digital transition unfolds across urban, suburban, and rural Estonia, analyzing jointly the spatial distribution of digital infrastructure, IT companies, and IT workers, and distinguishing between market-led and state-supported connectivity in the development of digital infrastructure.

4. Case Study Context: Regional Development and Digital Infrastructure in Estonia

Estonia provides a valuable context to study how digitalization influences spatial development. With minimal regional policy intervention (Raagmaa, 2023), Estonia offers insights into how digital infrastructure and IT-related sectors evolve within a market-driven society. However, digital infrastructure development follows a more complex trajectory, combining market and public investments. Market forces strongly influence labor and housing markets (Aalbers, 2017; Çelik, 2024) as well as digital infrastructure access.

Private providers concentrate high-speed internet investments in affluent, densely populated areas, leaving rural regions behind (Galperin et al., 2021). This pattern is evident in Estonia. Private telecommunication companies prioritize economically viable urban and suburban areas with higher returns. However, the Estonian state has supported infrastructure expansion in peripheral and rural areas through targeted programs led by the Estonian Broadband Development Foundation (ELASA). Consequently, high-speed internet access, particularly 1 Gbps fiber optic connectivity, has become both a market-driven commodity and a state-facilitated public good. Established in 2009, ELASA has implemented the EstWin project, building over 6,000 km of backbone network by 2018 and expanding since 2021 to construct last-mile access networks in underserved rural areas using national and EU funding (ELASA, 2025; Majandus- ja Kommunikatsiooniministeerium, 2024).

This article explores how digital transition progresses across Estonia's settlement system, focusing on major urban centers (Tallinn and Tartu), suburban areas, and rural regions. Tallinn serves as the economic hub, while Tartu is the center of education and innovation. Suburban areas are the functional urban regions of Tallinn and Tartu, characterized by intense commuting and ongoing urban sprawl that extends almost 100 km from the city in Tallinn and 50 km in Tartu, offering attractive living environments, fast internet, and close access to jobs (Majandus- ja Kommunikatsiooniministeerium, 2025). Beyond these urban regions, smaller towns and rural areas face uneven development trajectories. Although Estonia is recognized for early e-governance adoption and widespread online services, significant spatial disparities in digital access persist. Income inequality is relatively low by OECD standards (OECD, 2025), yet it intersects with digital divides, potentially reinforcing unequal access to labor and housing markets (Kalmus et al., 2013; van Dijk, 2020). This study analyzes how digital transition affects urban, suburban, and rural settlements through the spatial distribution of digital infrastructure, IT companies, and workers.

5. Data and Methods

5.1. Data

This study integrates multiple data sources to provide a comprehensive analysis of how the digital transition intersects with spatial development along three key dimensions: the availability of fast internet infrastructure, the business location of IT companies, and the residential location patterns of IT workers. These dimensions reflect the technological, economic, and demographic aspects of digital transformation. To enable consistent comparison across data types, all datasets were harmonized and aggregated at the settlement level, even in cases where more granular, address-level data were available. This approach ensures analytical coherence while maintaining statistical robustness. In accordance with data protection and anonymity requirements, all settlements with a population below three were excluded from the analysis to prevent potential identification of individuals in very small communities.

First, we use cable internet access data from the Consumer Protection and Technical Regulatory Authority. We focus exclusively on fiber optic cable internet because, in the Estonian context, a 1 Gbps fiber optic connection is widely regarded as a proxy for stable and high-speed internet access. Our analysis examines the availability of such connections at two points in time: 2019 and 2023, corresponding to the period before and after the global Covid-19 pandemic, which markedly accelerated digital transitions worldwide. Importantly, the data allow us to distinguish between networks developed commercially by private telecom operators in response to market demand, and those established through public sector initiatives (including EU funds and national government support) intended to address market failures in less profitable areas for telecom companies. To capture variation access across settlements, we classify connections into three categories: fast internet (1 Gbps), slow internet (less than 1 Gbps), and no cable internet connection.

Second, we utilize data from the Estonian Business Registry, which contains detailed information on company addresses and fields of economic activity for the year 2023. The location data is provided both for headquarters as well as actual operation units for larger companies. While digital technologies permeate virtually all sectors of the economy, this study adopts a narrow operational definition of IT companies to ensure analytical clarity. Using the official Classification of Economic Activities in the European Community (NACE codes), we identify and extract companies whose primary activities fall within core information technology fields. The specific activity codes included in our classification are presented in the Supplementary File, Table 1. This approach allows us to distinguish IT companies from other types of businesses and to map their spatial distribution across Estonian settlements.

Third, we incorporate individual-level data from the 2021 Estonian Population and Housing Census, which provides detailed information on residents' employment sectors and home locations. This dataset enables us to identify individuals working in the IT sector and analyze their residential patterns in relation to broader spatial development and digital infrastructure dynamics.

Our analysis compares IT sector workers and companies to all other sectors combined. While 'other sectors' encompasses a diverse range of industries, this broad comparison serves our analytical purpose of identifying the distinctive spatial concentration patterns of the IT sector. IT workers constitute a clearly defined occupational group with sector-specific characteristics—high salaries, remote work capability, and digital infrastructure dependency—making them analytically distinct from the general workforce. This approach allows us to assess whether IT sector spatial patterns differ fundamentally from overall employment distributions across the settlement system.

5.2. Methods

The spatial unit of analysis in this study is the settlement, which represents the most granular territorial division in the official Classification of Estonian Administrative Units and Settlements (Eesti Statistika, 2025). This approach allows for a high level of spatial precision and comparability across datasets. In total, data were obtained for 4,715 settlement units, although this number may vary slightly between data sources and over time due to administrative updates and reclassifications within the national settlement system. Special analytical focus is placed on Estonia's two largest urban centers—capital city Tallinn and second-largest city Tartu, hosting the main university of the country—and the suburbs surrounding them, as these are two main hubs of digital transition in Estonia. These two urban regions are delineated based on functional relationships, specifically by identifying areas where at least 50% of the employed population commutes to the urban core. This commuting-based definition captures broader urban influence zones and better reflects contemporary patterns of residential location and economic integration. In the accompanying maps, place names correspond to the central settlements of these functional city-regions (Hägerstrand, 1967).

Our analysis starts with a ranking-based assessment of spatial patterns of economic activity, which is particularly suited to Estonia's highly uneven spatial structure—characterized by a small number of dominant urban centers and a large number of sparsely populated small towns and rural settlements. While Location Quotient (LQ) analysis (Isard, 1960) is commonly used for evaluating relative concentration of economic activity, its effectiveness can be limited in contexts with significant spatial inequality, making rank-based approaches more appropriate for our case. This methodological choice reduces the distorting effect of extreme disparities in absolute values and facilitates more meaningful comparisons across settlements of different sizes. To evaluate the distribution of IT-related activity, we rank settlements along two dimensions: the share of IT companies relative to all companies located in a settlement, and the share of IT workers relative to the total employed population residing in each settlement. These two sets of rankings will then be compared by calculating rank differences for the top 500 settlements in each category. By focusing on this subset, we minimize the statistical noise associated with very small settlements where IT activity is negligible, allowing for a more robust comparison. In a nutshell, the resulting rank differences reveal the relative over- or under-representation of IT companies operating and IT workers residing in each settlement. This ranking approach addresses a key statistical challenge visible in our data: In settlements with very few IT workers or companies (typically fewer than five), small absolute numbers create high variance that obscures underlying spatial patterns. By focusing on the top 500 settlements, we capture areas where IT activity is sufficient for reliable statistical comparison, while avoiding spurious patterns driven by random variation in very small settlements.

Next, Ripley's *K* function is employed to analyze the spatial clustering and interaction between fast internet access and the locations of IT companies and IT workers (Baddeley & Turner, 2005). This method is well-established in spatial economics for detecting agglomeration effects and identifying the geographic extent of business clustering. As a second-order spatial statistic, Ripley's *K* function evaluates point pattern distributions across a range of distances, enabling us to detect spatial clustering or dispersion beyond what would be expected under complete spatial randomness. In particular, the bivariate (or cross) K function is used to assess whether two different types of spatial features—such as internet access points and IT company locations—tend to occur near each other (indicating attraction or clustering) or farther apart (suggesting repulsion or dispersion). When the empirical $K(r)$ values lie above the theoretical expectation under spatial randomness, this indicates clustering at distance r; values below suggest spatial avoidance or dispersion. Results are presented as curves that plot $K(r)$ against distance r, accompanied by confidence envelopes derived from Monte Carlo simulations. These envelopes provide a statistical benchmark, helping to determine whether the observed spatial patterns significantly deviate from randomness. For visualization, we used Ripley's L function, which is just a transformation of Ripley's K that makes it easier to interpret. Both measure spatial clustering identically, but L centers around zero under complete spatial randomness: Values of $L(r) > 0$ indicate clustering at distance r, while $L(r) = 0$ corresponds to random distribution. This approach enables a nuanced understanding of spatial dependencies and synergies between digital infrastructure and the geography of IT businesses and IT workers.

A spatial lag model is then employed to examine potential spatial spillover effects in the residential locations of IT workers (Bivand & Piras, 2015). This model captures how neighbouring settlements influence one another, recognizing that IT workers might cluster not only due to characteristics of individual settlements but also because of broader regional dynamics around each settlement. Such spillover effects may arise from agglomeration economies, knowledge diffusion, or shared infrastructure, which together foster the formation of spatially connected housing and labor markets. We use spatial lag regression because IT worker distribution shows spatial autocorrelation—nearby settlements influence each other. Standard regression would miss these neighborhood effects and produce biased results.

To further explore how the digital infrastructure and the spatial concentration of IT workers relate to income disparities across settlements, we apply analysis of variance (ANOVA) to test for statistically significant differences in mean income levels among settlement groups characterized by varying degrees of internet access and IT employment share. Where ANOVA assumptions, such as homogeneity of variances, were not satisfied, the Kruskal-Wallis test, a non-parametric counterpart, was used to ensure robustness of results. Post-hoc comparisons are conducted using the Duncan multiple range test, which allows for pairwise group comparisons while controlling for type I error. This multi-method approach enables a more nuanced understanding of how digital transition evolves at the settlement level.

Several methodological limitations warrant acknowledgment. Rank-difference analysis reveals relative patterns but does not capture absolute magnitudes or test statistical significance. Ripley's K assumes uniform spatial distribution under the null hypothesis, which may oversimplify Estonia's transport networks and geographic barriers. Spatial lag models capture average spillover effects but assume these are constant across all locations, potentially masking regional variations between metropolitan and peripheral areas.

6. Results

To test our conceptual framework (see Figure 1), we examine three key indicators. First, we map high-speed internet infrastructure to see whether it follows existing urban hierarchies or reaches peripheral areas through public investment. Second, we analyze where IT companies locate to assess whether digital transition concentrates jobs in cities or enables spatial dispersion. Third, we examine where IT workers live to understand how remote work flexibility affects residential choices. These three measures allow us to assess the impacts of digital transition on urban, suburban, and rural areas.

6.1. Spatial Distribution of Digital Infrastructure in Estonia

Estonia's digital infrastructure shows significant spatial disparities. In 2023, 5.4% of residents (71,280 people) lived in settlements without cable internet, despite these areas covering 46.3% of the country's territory (Maa- ja Ruumiamet, 2025). Although cable networks reach 46.8% of all buildings, only 27.2% are connected to high-speed fiber-optic networks (1 Gbps). This mismatch highlights a persistent digital divide across Estonian settlements, as shown in Figure 2, with consequences for remote work access and regional competitiveness.

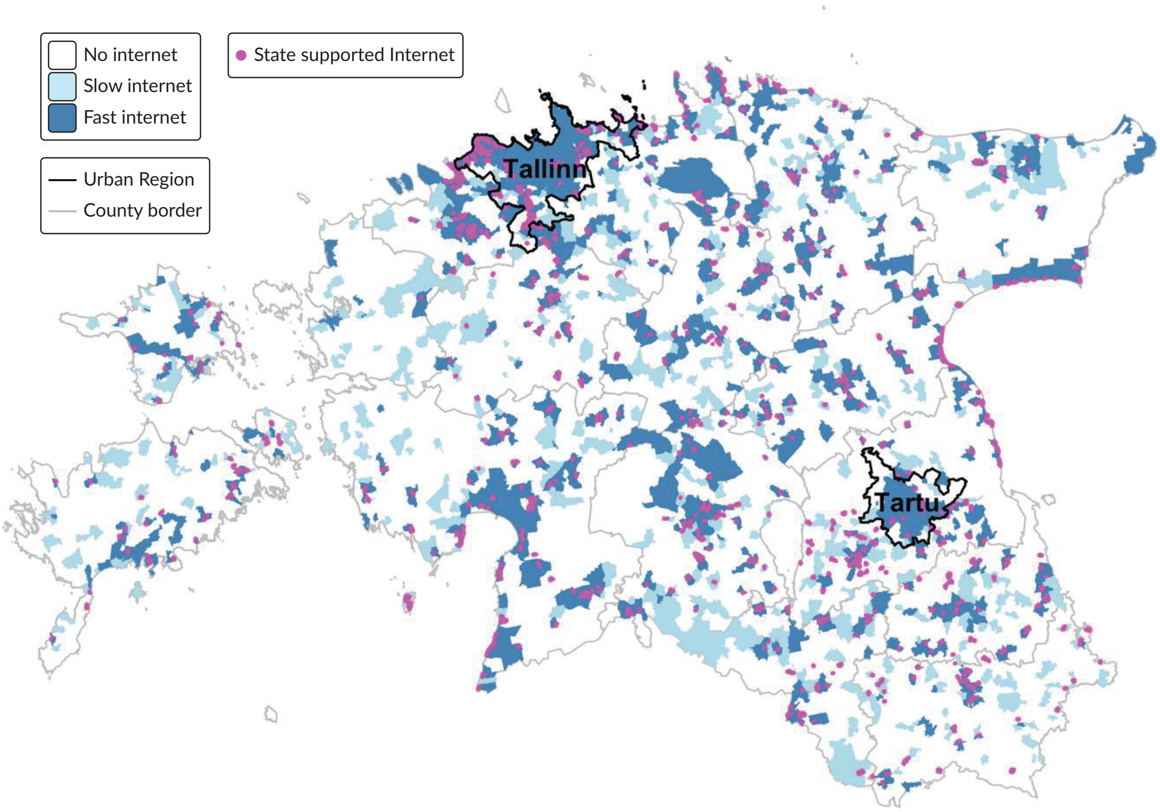

Figure 2. Availability of fiber optic and other cable Internet in settlement units (2023).

The spatial distribution of fast internet in Estonia reveals a pronounced urban–suburban–rural gradient. Urban settlements exhibit near-universal connectivity, whereas rural areas continue to face substantial service gaps. To address delays in the development of digital infrastructure in rural areas, Estonia has adopted a dual-track strategy that combines market-led investments with targeted public interventions. The ELASA has played a key role in addressing market failures by extending broadband infrastructure to peripheral and sparsely populated areas. Through its targeted efforts, the foundation has supported the development of fast internet in 691 settlement units (representing 14.7% of all settlements in the country), which are home to 16.2% of Estonia's population. This complementary approach has yielded varying results, depending on the type of actor involved. While private sector providers tend to concentrate their efforts on densely populated and commercially viable areas—often excluding more remote rural areas—public infrastructure projects are more likely to ensure access to fast internet even in sparsely populated settlements, thereby helping to reduce spatial digital inequalities. As a result, public-sector-built fast internet networks now span a larger share of Estonia's territory—59.8% of all settlements—despite serving a smaller share of the population (Table 1). These patterns underscore the magnitude of remaining infrastructure challenges, with an estimated EUR 828 million in additional investment required to achieve universal high-speed coverage in rural areas (Majandus- ja Kommunikatsiooniministeerium, 2024).

Table 1. Internet availability in settlements.

	Fast	Slow
Private sector providers	40.2%	89.1%
State-supported infrastructure	59.8%	10.9%

6.2. Spatial Distribution of IT Companies

6.2.1. Distribution Patterns

IT companies are heavily concentrated in areas with high-speed internet. In settlements with 1 Gbps connectivity, IT companies account for 7.8% of all enterprises, compared with just 2% in areas with slow or no cable internet (Table 2). This difference is statistically significant (χ^2 = 529.56, p < 2.2e-16), showing regional variation that public infrastructure investments only partly reduce.

Table 2. Distribution of IT and other companies by internet availability.

	Fast	Slow	No Internet
IT companies	7.8%	2.1%	1.9%
Other companies	92.2%	97.9%	98.1%

Spatial clustering of IT companies has resulted in higher concentrations in the two main cities of Tallinn and Tartu and their surrounding suburbs (Figure 3). Statistical analysis confirms IT workers are not randomly distributed across settlements (χ^2 test, p < 2.2e-16). Notably, IT workers are markedly overrepresented—by a factor of three to four—in areas equipped with high-speed internet (1 Gbps) compared to settlements with slow or no cable internet access. This overrepresentation reinforces the interpretation that fast digital infrastructure is not merely an enabling condition for IT business operations, but also a key factor influencing where IT companies are located. The concentration of IT companies in well-connected areas underscores the emergence of spatially selective digital ecosystems.

Ripley's L function analysis confirms pronounced spatial clustering of IT companies, strongly correlated with access to high-speed internet infrastructure (Figure 4). L values consistently exceed zero across all connectivity zones but rise most steeply in high-speed (1 Gbps) areas, indicating dense agglomerations. This pattern confirms that fast internet facilitates digital innovation hubs where companies benefit from good connectivity, proximity, shared infrastructure, and knowledge spillovers. Areas with limited connectivity show considerably weaker clustering.

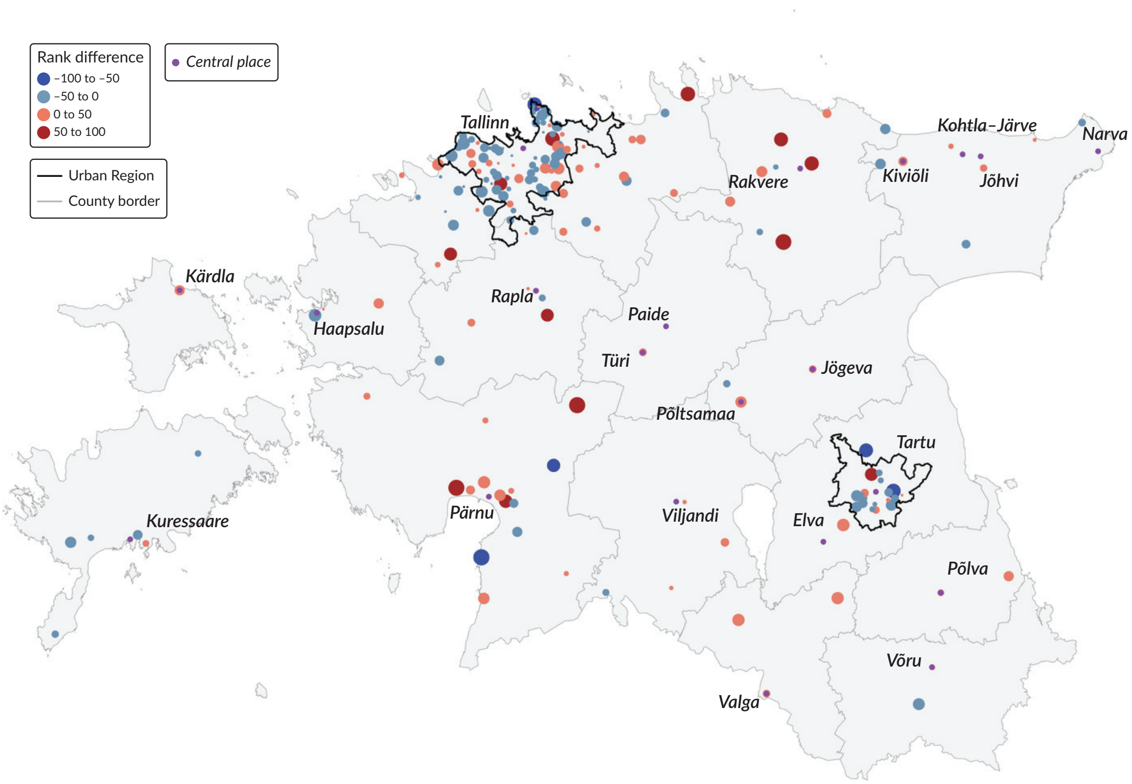

Figure 3. Placement differences between IT and other companies. Notes: Rank difference calculated as IT company rank minus other company rank for each settlement; blue dots indicate settlements where IT companies are overrepresented relative to their population/company base; red dots indicate underrepresentation.

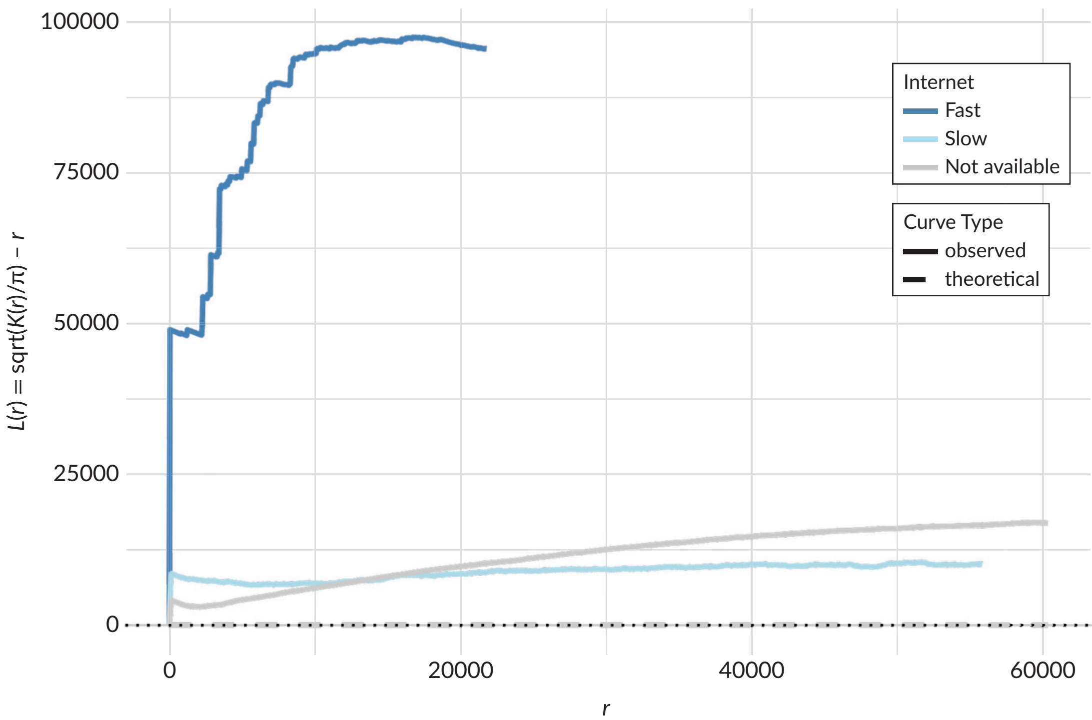

Figure 4. Ripley's *L* function of clustering of IT companies in settlements with different internet availability.

6.2.2. Temporal Dynamics

Figure 5 illustrates the spatial distribution of newly established IT and other companies across Estonia, contextualized by the availability of internet infrastructure. The analysis reveals a clear and intensifying concentration of these new IT companies in areas equipped with high-speed (1 Gbps) internet access after the outbreak of Covid-19 pandemic. Among companies established during the 2022–2023 period, 12.1% of those located in areas with 1 Gbps connectivity belonged to the IT sector, compared to just 2.8% in areas with slower internet and 2.5% in settlements without cable internet access (see Figure 5 and Table 3). This stark contrast points to a growing spatial divergence in the development of the digital transition whereby already well-connected regions are capturing an increasingly disproportionate share of new IT companies. While the overall share of IT companies in fast internet areas stands at 7.8% (Table 3), the considerably higher figure of 12.1% for new IT businesses suggests that fast digital infrastructure has become a crucial catalyst for the formation and growth of the technology sector. This temporal trend highlights the importance of fast internet availability for regional development. Notably, settlements that gain from public-sector-supported access to high-speed internet exhibit similar outcomes to those with market-provided connectivity. This suggests that although public investment helps close the technological gap by expanding infrastructure access, these investments are not enough to close the connectivity-gap for rural areas. Expanding connectivity and converting it into economic gains through business attraction may require more time and additional complementary policies.

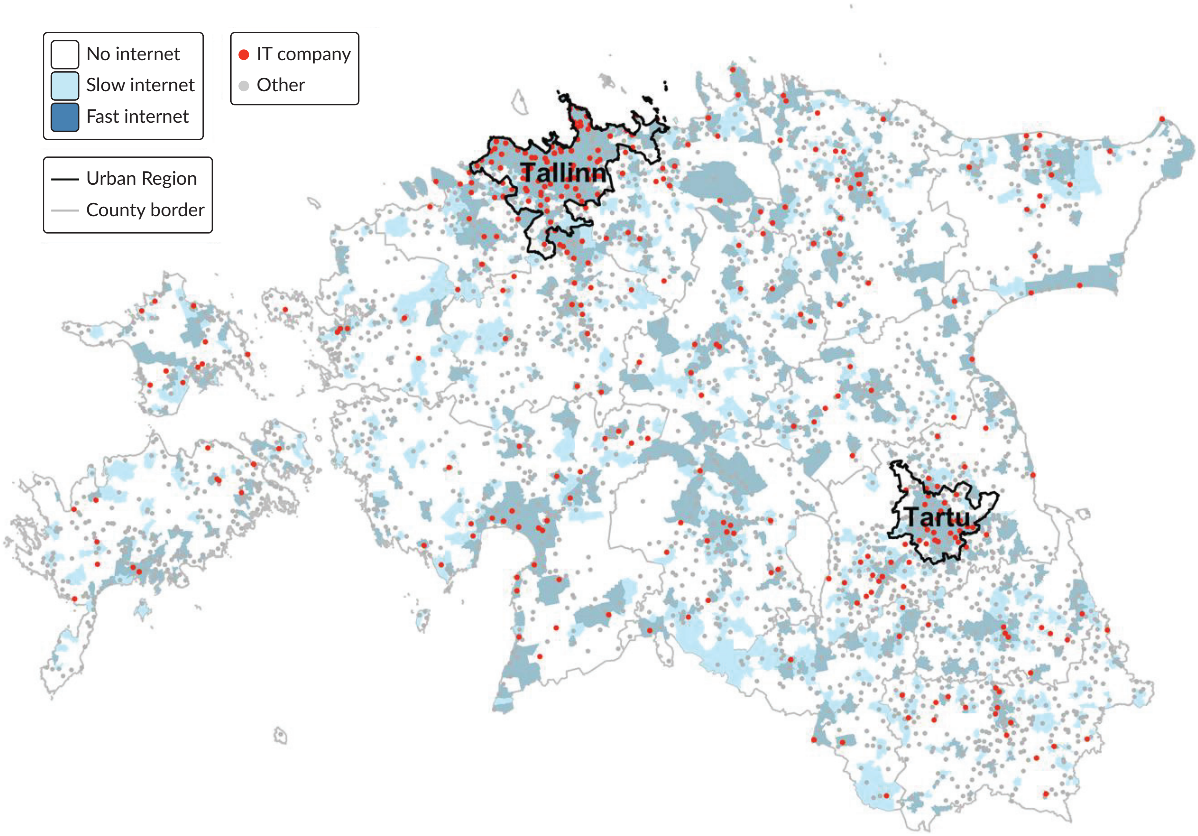

Figure 5. Distribution of established IT companies (> 2021) vs availability of the internet.

Table 3. Share of IT companies (first registered after 2021) vs internet access.

	Fast	Slow	No Internet
IT	12.1%	2.8%	2.5%
Other	87.9%	97.2%	97.5%

6.3. Residential Distribution of IT Workers

6.3.1. Spatial Distribution

Like IT companies, IT workers exhibit markedly different residential patterns compared to the general workforce. While all employed individuals are distributed across 4,466 settlement units (representing 95.0% of all Estonian settlements), IT workers reside in only 2,382 of them, or 50.1%. The capital city of Tallinn is the home of the highest share of IT workers. A more detailed rank-difference analysis of the 500 most populated settlements further highlights systematic overrepresentation of IT workers in suburban areas surrounding Estonia's major cities, particularly Tallinn and Tartu (Figure 6). Within the metropolitan areas, workers are strongly clustered in the suburbs compared to the location of IT companies. Prominent residential clusters emerge along the suburban corridors of Tallinn–Rapla and Tartu–Elva, suggesting that IT workers prefer settlements that offer a combination of proximity to urban job centers, good connectivity to

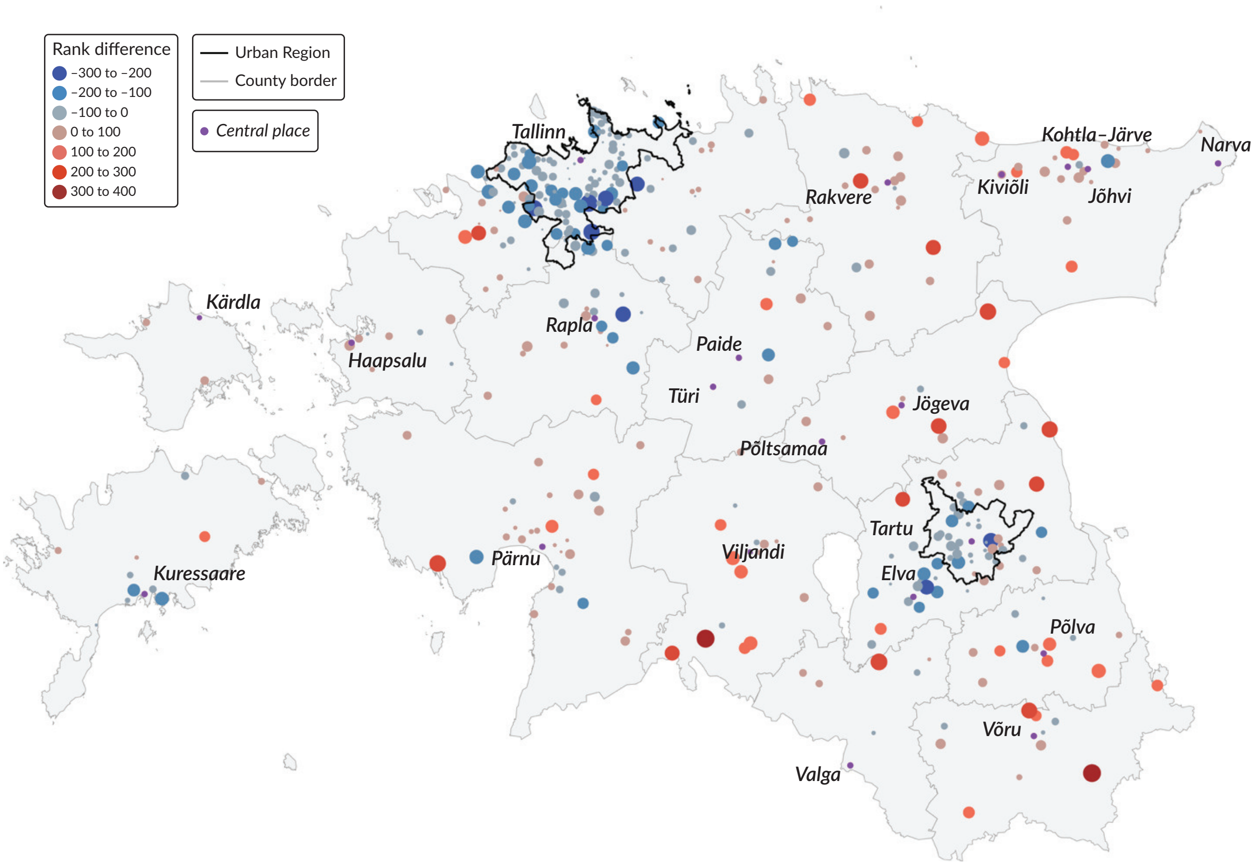

Figure 6. Home locations of IT workers for each settlement. Notes: Rank difference calculated as IT worker rank minus other worker rank; blue dots indicate settlements where IT workers are overrepresented; red dots indicate underrepresentation; dot size reflects the magnitude of rank difference.

the core city, and enhanced residential amenities in the settlement of residence. The residential clusters of IT workers thus extend beyond the immediate suburban rings of Tallinn and Tartu, reaching into more distant, ex-urban settlements. In contrast, the spatial pattern of IT companies remains more tightly concentrated in core urban areas, where institutional infrastructure, dense business ecosystems, and agglomeration economies offer strategic advantages for company location and growth.

6.3.2. Spatial Dependence

The spatial lag regression analysis reveals a statistically significant spatial autocorrelation in the residential distribution of IT workers, underscoring the presence of spatial proximity effects in their residential decision-making. The model, which includes the number of workers in other sectors, total population size, and a spatially lagged dependent variable, confirms that IT workers are not randomly distributed across the settlement system. Instead, they tend to cluster in contiguous groups of neighbouring settlements, indicating a pattern of residential proximity among IT workers. The spatial lag coefficient ($\rho = 0.057$, $p = 0.021$) confirms that the presence of IT workers in one settlement is positively associated with their presence in neighboring settlements. Although modest in magnitude, this coefficient suggests that approximately 5.7% of the variation in IT worker residential concentration can be attributed to elevated shares of IT workers in neighboring settlements.

This spatial clustering reflects broader agglomeration dynamics, where IT professionals stay close to the IT businesses located in core cities, but being drawn to neighbouring settlements often located in suburbs, probably due to factors such as attractive housing, neighborhood reputation, access to local amenities, social networks, shared infrastructure (such as fast internet and co-working spaces), and good commuting connectivity to the core city. In addition, the strong positive coefficient for other sector workers (0.513, $p < 2.2\text{e-}16$) indicates that IT worker concentration is closely tied to overall employment levels, while the negative coefficient for population size (–0.197, $p < 2.2\text{e-}16$) suggests that smaller settlements, when controlling for total employment, are relatively more attractive to IT workers—likely due to lifestyle preferences and the availability of desirable housing. Together, these findings point to spatial logic in the residential sorting of IT professionals, who tend to concentrate on attractive urban and suburban environments.

6.3.3. Income Gains from IT Companies and Workers

IT companies and workers concentrate in large cities and suburban regions with high-speed internet, dense labor markets, and urban amenities. Since IT salaries are significantly higher than in other sectors and personal income tax is the main municipal revenue, these patterns affect settlement wealth. We examine how the availability of fast internet correlates with per capita income. The Kruskal-Wallis test ($\chi^2 = 137.59$, $df = 2$, $p < 2.2\text{e-}16$) and ANOVA ($F(2.4584) = 43.7$, $p < 2.2\text{e-}16$) confirm income levels vary systematically across connectivity categories. Mean income estimates show a clear gradient: Settlements with high-speed internet (1 Gbps) have an average per capita income of EUR 12,224 (± EUR 4,037), compared to EUR 11,088 (± EUR 2,852) in areas with slower connections and EUR 10,813 (± EUR 4,069) in settlements lacking fast cable internet altogether (Figure 7).

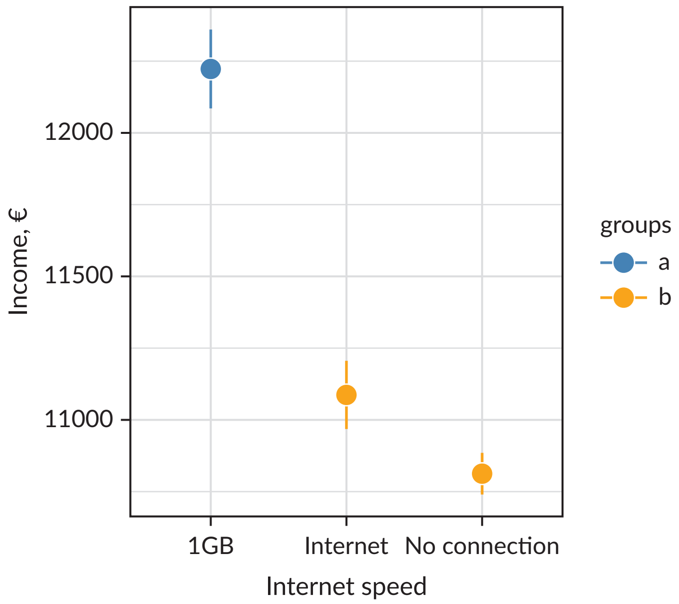

Figure 7. Annual income per capita in areas with different Internet connectivity (fast internet, slow internet, no internet).

Duncan's test ($\alpha = 0.01$) reveals two groups: Settlements with high-speed internet exhibit a 12.9% income premium over those with slow or no connectivity, reflecting economic gains associated with better business conditions, higher-skilled employment opportunities, and expanded remote-work options.

Higher incomes concentrate in and around Tallinn and Tartu urban regions (Figure 8), where high-speed internet coverage is most extensive. This overlap suggests a reinforcing dynamic: Both urban and suburban

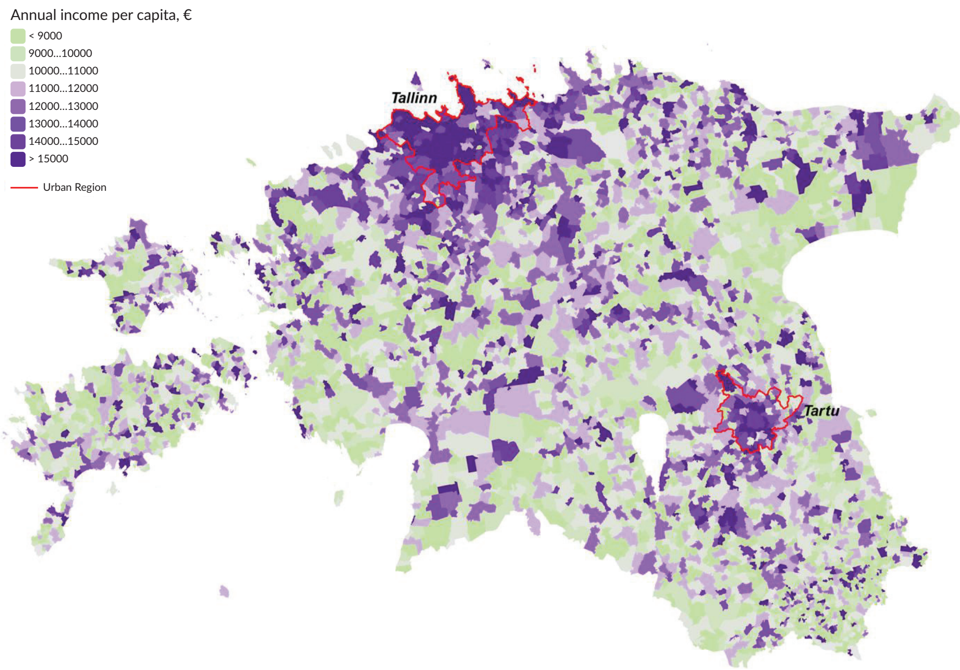

Figure 8. Annual income per capita in settlement (2022).

areas benefit from both stronger economic activity and better digital infrastructure, while peripheral areas remain disadvantaged. High-speed internet enables peripheral areas to access emerging technologies, attract IT companies and workers, and enhance economic development.

6.3.4. Combined Effects of IT Concentration and Infrastructure

To quantify the combined influence of IT worker concentration and internet speed on income, we estimated a linear regression: Income per capita ~ IT worker share + Internet speed class. Both predictors are significantly associated with income levels: IT worker share ($\beta = 56.17$, SE = 17.29, $p = 0.001$) and internet speed class ($\beta = 24.68$, SE = 8.85, $p = 0.005$). Although the model explains modest variance ($R^2 = 0.004$, F (2,4589) = 9.73, $p < 0.001$), both predictors contribute significantly to income differentiation across settlements.

Stratified analysis (Figure 9) shows the highest income levels in settlements combining high-speed internet and high IT worker concentration. Infrastructure alone is not associated with economic gains, nor do IT workers

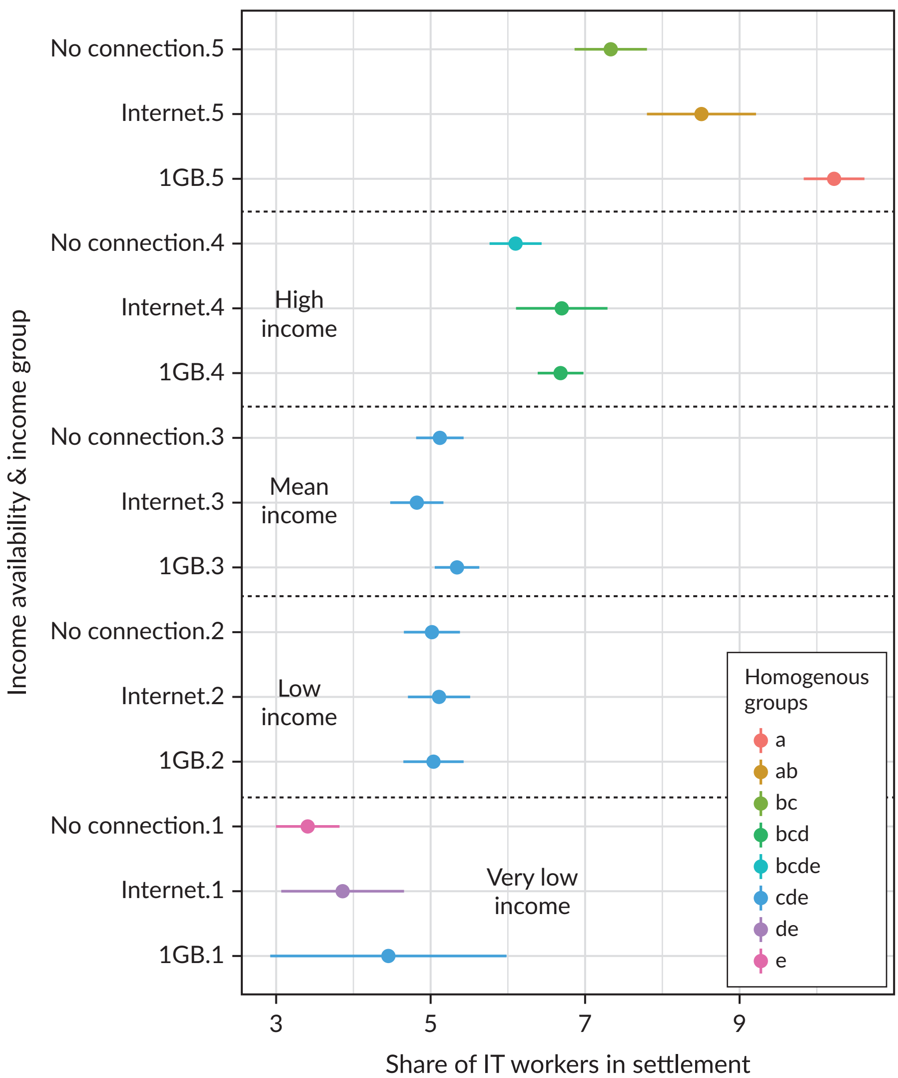

Figure 9. Share of IT workers in settlements by availability of internet and income class (scale: 1, very low income, to 5, very high income).

generate full impact without supporting infrastructure. Economic benefits are associated most strongly with the co-location of both infrastructure and companies, particularly in smaller towns and peri-urban areas.

7. Discussion of Key Findings

This study set out to examine the spatial dynamics of digital transition by analyzing how the availability of fast internet infrastructure correlates with the location of IT companies, the residential patterns of IT workers, and income disparities across settlements. While existing research often conceptualizes digital transition through a binary urban–rural lens, this study adopts a more differentiated spatial perspective—distinguishing between urban cores, suburban belts, and rural peripheries—to better understand the complex and uneven geography of digital opportunity. The empirical focus is on Estonia, a country widely recognized for its advanced digital public services and early adoption of e-governance. At the same time, Estonia offers a revealing case of minimal regional policy intervention—except for one critical area: Publicly subsidized investments in high-speed broadband infrastructure targeting underserved settlements. This contrast between a highly digitalized national environment and a largely market-led regional development provides a unique opportunity to investigate how digital infrastructure shapes spatial inequalities.

Our first research question asked whether the location of digital infrastructure follows existing regional divides. The findings reveal that digital infrastructure does not emerge in a spatial vacuum but closely tracks population distribution and pre-existing urban hierarchies. High-speed internet availability is heavily concentrated in major urban centers and their suburbs, mirroring broader patterns of centrality and reinforcing them. While Hägerstrand's (1967) theory of innovation diffusion emphasizes outward spatial spread, our results indicate that fast internet provision remains largely confined to urban cores and specific corridors, such as Tallinn–Rapla and Tartu–Elva, where residential amenity and economic opportunity align. Digital transition further reinforces the command-and-control centers of large cities in the global and national economies (cf. Sassen, 1991, challenging overly optimistic narratives of universal connectivity). However, our findings also show that public sector intervention plays a critical role in mitigating the unevenness associated with purely market-driven investments in fast internet. In Estonia, while commercial providers have concentrated on dense, high-return areas, the state—through the ELASA—has stepped in to fill market gaps in exurban and sparsely populated rural regions.

Our second research question focused on how the availability of fast internet influences the spatial distribution of companies, particularly those in the IT sector, relative to other companies. Our results show that the relationship between digital infrastructure and IT company location is particularly strong. Areas with 1 Gbps connectivity host nearly four times as many IT companies as those without, supporting Fielding's (1989) escalator region concept, showing that large cities, along with their suburbs, act as the main attractors of IT companies. In the case of Estonia, these are the two major cities, Tallinn as the capital and Tartu as the main center of higher education.

Furthermore, the concentration of IT companies in major urban regions has become even more pronounced since the acceleration of digital transition following the outbreak of the global Covid-19 pandemic. Peripheral settlements in Estonia that lack high-speed internet are increasingly underrepresented in providing IT sector jobs. Although public investments in fast internet networks have contributed to a more equitable distribution of access to the opportunities of the digital society, companies continue to favor the dynamic labor markets of large cities in their location decisions. This is particularly concerning given the observed trend that new IT companies are increasingly concentrated in already well-connected areas. If left unaddressed, such patterns risk deepening territorial inequalities and reinforcing the perception of being "left behind," particularly in rural and remote communities—echoing Rodríguez-Pose's (2018) warning about "the revenge of the places that don't matter" where regions excluded from global economic flows risk developing social and political discontent.

Our third research question examined how fast internet availability correlates with IT worker residential distribution. Findings reveal pronounced spatial clustering of IT workers compared to other sectors. These clusters are located not only in Estonia's most globally connected cities but also in the surrounding suburban areas that offer a combination of fast internet, attractive living environments, and proximity to employment centers. Unlike IT companies, which remain tightly clustered in core urban areas, IT workers are more spatially dispersed, extending into suburban and even peri-urban locations—particularly along major transport corridors that facilitate easy access to city centers. This pattern reflects the growing relevance of remote work in shaping residential decisions of IT professionals (Zālīte et al., 2025), in line with the "donut effect" proposed by Ramani and Bloom (2021).

Spatial lag regression results indicate modest yet statistically significant spatial spillover effects: Settlements with a high share of IT workers tend to be located near others with similar concentrations. This suggests that IT professionals are influenced by both local amenities and broader regional dynamics. These findings support Malecki's (2003) argument about the importance of "place-based assets" in the digital economy—such as housing quality, lifestyle, and soft infrastructure—and are consistent with Luca et al. (2025), who argue that digital workers are increasingly drawn to high-amenity suburbs that combine digital connectivity with a high quality of life. These settlements are also characterized by higher levels of per capita income, suggesting that the residential clustering of IT workers reflects not only lifestyle preferences and digital connectivity but also underlying wealth divides, as Estonian municipalities rely heavily on personal income tax and IT sector employees typically earn the highest salaries. The residential pattern of IT workers thus underscores how the spatial concentration of digital professionals contributes to income disparities between settlements, even more so than the location of IT companies themselves.

It is important to emphasize that these conclusions apply specifically to the IT sector and its workforce. The spatial patterns observed—concentration of companies in urban cores and residential dispersal of workers into suburbs—reflect characteristics unique to IT employment, including high salaries, remote work feasibility, and dependence on digital infrastructure. Other sectors affected by digital transition may exhibit different spatial dynamics. For instance, creative industries, financial services, education, or healthcare sectors utilizing digital technologies could show alternative patterns of concentration or dispersal. Some digitally-enabled sectors may offer greater benefits to rural areas than IT does, particularly those less dependent on urban agglomeration economies or face-to-face collaboration. Understanding these sector-specific variations remains an important avenue for future research on the spatially differentiated impacts of digital transition.

This study shows that the benefits of digital transition are spatially uneven, with urban and suburban areas emerging as primary winners. High-speed internet infrastructure, IT company formation, IT worker residence, and income levels are all disproportionately concentrated in urban cores and their surrounding suburban belts. The findings thus call for moving beyond the urban–rural dichotomy to better understand the spatial impacts of digital transition. Estonia's most globally connected cities, Tallinn and Tartu, attract the majority of IT companies due to their dense labor markets, institutional ecosystems, and agglomeration advantages. Yet it is suburban and exurban areas along major transport corridors that increasingly attract IT workers, offering digital connectivity, residential amenities, and access to urban job centers. These areas benefit not only from infrastructure but also from their capacity to host remote workers seeking quality of life, underscoring the growing role of place-based assets in the digital economy. Rural areas remain clearly disadvantaged: They host fewer IT jobs, attract fewer digital professionals, and lag in income. While Estonia's public broadband investments have helped narrow this divide, market-led distribution of fast internet deepens regional divides. In sum, the digital transition favors those regions that combine infrastructure, dynamic labor markets, human capital, and residential appeal—placing core urban areas as winners for IT company locations and suburban zones at the forefront of digital gains.

To conclude, these findings carry important implications for European regional policy debates. First, infrastructure investment alone is insufficient. While public broadband funding prevents digital exclusion, connectivity does not automatically translate into economic benefits. Policies must go beyond "laying fiber" to support conditions enabling peripheral regions to capture value from digital transition—including business support, digital skills training, and strategies to attract knowledge workers.

Second, rural areas face fundamental challenges. Without dense labor markets or agglomeration economies, rural regions struggle to attract IT companies even with fast internet. However, they may benefit by attracting remote workers rather than businesses. Policies enhancing rural quality of life—housing, services, amenities—combined with digital infrastructure may enable rural participation in the digital economy as residential rather than production spaces.

Finally, market-led infrastructure provision systematically disadvantages peripheral areas. Estonia's targeted public intervention demonstrates potential to mitigate spatial inequalities, though the timeframe since major investments remains too short for definitive conclusions about long-term impacts. For European cohesion policy, this underscores the need for sustained place-based infrastructure investments alongside broader digital strategies and long-term monitoring. Addressing digital divides requires continued public commitment as a fundamental question of spatial justice and regional development.

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Conflict of Interests

The authors declare no conflict of interests. In this article, editorial decisions were undertaken by Ulf R. Hedetoft (University of Copenhagen).

Data Availability

To use the data used in the study, please contact the authors.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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