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DRIVERS OF REGIONAL DIGITAL DIVIDE IN UZBEKISTAN AND MECHANISMS FOR EXPANDING MARKET INTEGRATION OF SMALL BUSINESS ENTITIES

Pazilidinov Muxiddin Maxammadin o'g'li
Senior Lecturer, Namangan State University
Tel: +998995389595; E-mail: m.muhiddin1995@gmail.com

Abstract *– Rapid digitalization has raised national aggregates but may conceal territorial inequality that limits the participation of provincial small businesses in electronic commerce. This study examines the regional digital divide in Uzbekistan and mechanisms for expanding the market integration of small business entities. Three official datasets of the National Statistics Committee were combined: annual gross value added of the information economy and e-commerce for 2015–2024, average nominal wages in information and communication and individual internet subscribers per 100 population for 14 administrative entities for 2015–2025. Spatial disparity indicators, correlation analysis, convergence tests and an ordinary least squares model of log gross value added on log internet density and log information-sector wages were applied. National gross value added grew 15.5-fold to 60,219.5 billion soums. Inequality in internet density fell sharply, with the coefficient of variation declining from 0.79 to 0.32, yet Tashkent city retained 168.2 subscribers per 100 people against 61.8 in Surkhandarya and 70.7 in Namangan, and wage dispersion outside the capital did not narrow. The national regression explained 99.0 percent of variation; the wage elasticity was 1.55 and significant, whereas internet density was individually insignificant because of severe multicollinearity, and first-difference estimates were weak. The evidence indicates co-movement rather than causation, and the hypothesis on regional integration could be examined only through proxies because regional small business sales data were unavailable. Four policy mechanisms are proposed: targeted regional broadband subsidies with cloud logistics hubs, tax incentives for regional information technology outsourcing, cooperative digital storefronts, and microfinance with digital literacy vouchers.*

Keywords: *regional digital divide, small business integration, electronic commerce, gross value added, ICT infrastructure, internet penetration disparity, wage inequality, econometric modeling, digital ecosystem, Uzbekistan*

INTRODUCTION

Digital technologies have become a general-purpose infrastructure of economic activity. By lowering the costs of search, replication, transportation, tracking and verification, they weaken the traditional link between location and market access [10], and they allow firms to be reached by customers, suppliers and financiers far beyond their home locality. Digital platforms and electronic commerce are the most visible channels of this change for small and medium-sized enterprises (SMEs), because they offer low-cost entry into national and cross-border marketplaces and provide the data and payment services that small firms rarely produce internally [16; 20].

The distribution of these benefits is, however, uneven. The digital divide is no longer understood as a simple gap in connection to the network; it is a multi-level phenomenon in which inequalities in physical and material access are followed by inequalities in skills and usage, and ultimately in the tangible outcomes that individuals and firms obtain from being online [23; 25; 26]. The World Development Report on digital dividends concluded that the returns to connectivity lag behind its spread when complementary conditions, such as skills, regulation and institutions, are missing [29], and international statistics continue to show persistent differences in connectivity between urban and rural populations [13].

Uzbekistan illustrates the scale of the digital leap. Gross value added created in the information economy and electronic commerce sector expanded from 3,876.3 billion soums in 2015 to 60,219.5 billion soums in 2024 [32], and the number of individual internet subscribers per 100 population rose from 25.8 to 78.7 over the same period [33]. This growth took place under the Digital Uzbekistan – 2030 Strategy, which links national digitalization to programs of regional and sectoral digital transformation [31].

The paradox that motivates this study is the coexistence of rapid macro-level digital growth with localized regional disparities. National aggregates are dominated by the capital, where telecommunication infrastructure, information and communication technology (ICT) employers and consumer demand are concentrated. Provincial SMEs, in contrast, operate in places with a thinner customer base for online services, fewer locally available technical specialists and higher effective logistics friction. Aggregate growth statistics do not reveal whether these regional barriers are narrowing, and, if not, which of them persists.

The aim of the study is to identify the drivers of the regional digital divide in Uzbekistan by measuring its evolution in telecommunication access and ICT wages, to estimate how these two dimensions are associated with the national volume of digital-economy value added, and to derive mechanisms for expanding the market integration of small business entities. The specific objectives are: (1) to describe the dynamics of national information economy value added, internet penetration and ICT wages in 2015–2024; (2) to quantify regional disparities across the 14 administrative entities of the country using dispersion, inequality and convergence indicators; (3) to estimate a multiple regression linking value added to internet penetration and ICT wages and to test its robustness; and (4) to formulate policy mechanisms consistent with the empirical evidence.

The object of the research is the regional digital economy of Uzbekistan. The subject is the mechanisms connecting infrastructure and wage disparities with the market performance of small business entities in electronic commerce. The research hypothesis is that bridging the gaps in telecommunication density and human capital significantly accelerates regional SME market integration. Because official data on SME e-commerce sales by region were not available, the hypothesis is examined through proxies: national digital-economy value added, regional internet density and regional ICT wages.

The scientific novelty of the study lies in three elements. First, it combines three official subnational and national datasets of the Statistics Agency of Uzbekistan in a single analytical frame. Second, it distinguishes convergence in access from divergence in human capital indicators and tests both with sigma and beta convergence measures. Third, it reports a transparent set of robustness checks that show the limits of what short national time series can reveal, and it derives policy mechanisms that are conditional on those limits.

LITERATURE REVIEW

Dimensions of the digital divide. The first generation of research treated the divide as unequal access to the internet. Later work distinguished a second level, concerned with skills and patterns of use, and a third level, concerned with the tangible outcomes obtained from use [23]. Van Dijk [26] integrated these levels in a sequential model in which motivational, material, skills and usage access follow one another, and van Deursen and van Dijk [25] documented that, as physical access saturates, the first-level divide shifts from inequalities in connection to inequalities in the quality and material conditions of access. Ragnedda [21] added the concept of digital capital, the combination of digital technology and digital competence that can be converted into economic and social advantage, and a recent review synthesizes the antecedents and consequences of the divide and calls for further research on its economic outcomes [17]. The critical implication for the present study is that access indicators such as internet subscribers per 100 population are informative but insufficient: they must be read together with indicators of human capital and, where available, of economic outcomes.

Digital infrastructure, spatial economics and SME market integration. Spatial economics explains why digital capacity clusters in large centers: increasing returns, market-size effects and transport costs generate core–periphery patterns [15]. Digital connectivity might be expected to weaken these forces, and empirical studies show that broadband raises growth and local activity: Czernich et al. [6] found positive growth effects of broadband penetration across OECD countries, while Kolko [14] reported positive but conditional associations between broadband and local growth in United States counties. Evidence from developing economies is similar in direction. Fast internet raised employment in African cities that it reached [12], while a randomized rollout of village e-commerce service centers in China produced large gains for rural consumers but only limited income gains for producers [4]. Studies of entrepreneurial ecosystems argue that the effect of digital affordances depends on spatial affordances, that is, on whether local actors, finance and complementary services are present [2]. For SMEs specifically, the OECD [20] identifies infrastructure, skills and finance as the main barriers to digital adoption, and Li et al. [16] show that the transformation of small firms depends on their capability to sense and seize digital opportunities rather than on technology access alone. Overall, the literature agrees that infrastructure is necessary, but it disagrees on whether it is sufficient, which is why the regional distribution of complementary assets matters.

Human capital disparities and ICT wages. Wage differentials in ICT occupations can be read as a proxy for the concentration of scarce technical talent. Moretti [18] showed that innovation-intensive occupations cluster in a small number of high-wage metropolitan areas and generate local multipliers that widen regional gaps. Combes et al. [3] found that spatial wage disparities are largely explained by differences in the skills of workers, that is, by sorting, together with agglomeration. Akerman et al. [1] showed that broadband complements skilled labor, and Forman et al. [9] found that internet investment was associated with wage growth only in a limited set of counties with favorable initial conditions, a puzzle that suggests that connectivity may widen rather than narrow local wage gaps. The brain-drain literature, although focused on international migration, shows that the emigration of the skilled can depress the local supply of human capital [7]; by analogy, internal migration from provinces to capitals may operate in a similar way. Microfinance and digital finance provide a complementary channel: mobile money improved household welfare and occupational choice in Kenya [24]. Regional ICT wages therefore capture both purchasing power and the local availability of technical skills, which supports their use here.

Regional disparities in transition and emerging economies. Comparisons among European Union member states show that digital gaps are related to socio-economic differences between countries [5]. Regional inequality is customarily measured by dispersion indicators and by tests of sigma and beta convergence [22; 27]. Applied analyses of digital development in Central Asian transition economies are less developed, and the studies known to the author do not combine official regional telecommunication density, sector-specific wages and national digital-economy value added in one empirical frame.

Identification strategies and their limits. Causal claims in the broadband literature rest on instruments or quasi-experiments, such as pre-existing telephone networks [6], the arrival of submarine cables [12] and the staggered municipal rollout of broadband [1]. These designs require variation in access that is exogenous to local conditions, and they are typically applied to firm-level or local labor-market data. National aggregate time series, in contrast, are exposed to common trends and to reverse causality, since a larger digital economy also finances more infrastructure and pays higher wages. The implication is that analyses based on aggregate official statistics can document association and disparity, but they should not be presented as evidence of causal effects, and their conclusions must be conditional on this limitation.

Measuring regional inequality. Dispersion measures such as the coefficient of variation and the weighted variants introduced by Williamson [27] remain the standard descriptive tools of regional economics, while the distinction between beta and sigma convergence [22] separates the catching-up of poorer regions from the reduction in overall dispersion. Applying both to digital indicators allows the analyst to test whether access and human capital converge at the same pace, which is a precondition for judging whether infrastructure programs also reduce the deeper divide in skills and incomes.

Research gap. Three limitations follow from this review. First, the divide literature stresses the third-level outcomes for firms, but it rarely quantifies them with official subnational statistics. Second, spatial and SME studies concentrate on advanced economies and on China, whereas evidence on Central Asian transition economies is scarce. Third, studies that use aggregate time series often overlook the statistical problems of short trending series, such as spurious correlation and multicollinearity [11; 28]. The present study fills the gap by supplying an empirical analysis that links official regional telecommunication density and ICT wages with national e-commerce and information-economy value added in Uzbekistan and by documenting the limits of inference from such data.

METHODOLOGY

The study used three official datasets published by the National Statistics Committee of the Republic of Uzbekistan (formerly the Statistics Agency) that were downloaded from the national statistics portal. The first dataset reported gross value added created in the sector of information economy and e-commerce (annual, billion soums, national level, 2015–2024) [32]. The information economy is defined by the statistical office as the group of aggregate indicators covering ICT, content, media and electronic commerce; the series was revised from 2017 in line with the 2008 System of National Accounts. The second dataset reported average nominal accrued monthly wages in the information and communication sector (thousand soums; national level and 14 administrative entities, 2015–2025) [34]; it excluded the wages of workers in small business entities. The third dataset reported the number of individual internet subscribers per 100 average resident population (national level and 14 administrative entities, 2015–2025) [33]. The 14 entities were the Republic of Karakalpakstan, the 12 provinces and Tashkent city. Values for 2012–2014 in the internet dataset showed abrupt breaks and were not used.

Internet subscribers per 100 population represented the accessibility of the market and the size of the online consumer base, ICT wages represented locally available specialized technical skills and purchasing power, and gross value added represented the commercial outcome of digital and e-commerce expansion. Regional internet density and regional wages were used to describe the divide, and the national series to estimate the association, because value added was not published by region.

Regional disparities were measured in three steps. First, dispersion across the 14 entities was measured by the coefficient of variation (CV), calculated with the population standard deviation, and by the Gini coefficient, calculated without population weights because regional population data were not part of the datasets. Second, the ratio of the maximum to the minimum value and the ratio of Tashkent city to the mean of the other 13 entities were computed. Third, sigma convergence was assessed by the time path of the CV, and absolute beta convergence by a cross-sectional regression of the average annual log growth rate over 2015–2024 on the log initial level. The indicators were defined as follows.

$$\mathrm{CV} = \frac{\sigma}{\mu}, \quad G = \frac{2\sum_{i=1}^{n} i x_{(i)}}{n\sum_{i=1}^{n} x_i} - \frac{n+1}{n} \tag{1}$$

$$\frac{1}{T}\ln\left(\frac{x_{i,T}}{x_{i,0}}\right) = a + b\ln x_{i,0} + u_i \tag{2}$$

where $x_{(i)}$ were the values sorted in ascending order, $n = 14$, $T = 9$ and a negative b indicated convergence. Pearson correlation coefficients were computed for the national series (in logarithms and levels) and for regional cross-sections, and Spearman rank correlations were computed as a check for outliers.

The datasets were downloaded in spreadsheet format with metadata, and each series was checked for units, coverage and structural breaks before analysis. The national row of each dataset was used for the time-series analysis, and the rows of the 14 entities for the regional analysis. Tashkent city was treated as a special case because of its size and the concentration of ICT activity, and all regional indicators were reported both with and without it. Statistical significance was assessed at the 5 percent level with two-sided tests, and t-distribution critical values were used for the confidence intervals of the regressions.

The association between national value added and its two drivers was estimated by ordinary least squares (OLS) on annual data for 2015–2024 (n = 10):

$$\ln GVA_t = \beta_0 + \beta_1 \ln Internet_t + \beta_2 \ln Wage_t + \varepsilon_t \qquad (3)$$

The double-logarithmic form was chosen because it stabilizes variance in exponentially growing series and gives coefficients that are interpreted as elasticities. Diagnostics comprised the coefficient of determination, the adjusted coefficient of determination, the F-statistic, t-statistics with two-sided p-values and 95 percent confidence intervals, the Durbin–Watson statistic [8], and the variance inflation factor, $VIF = 1/(1 - R_j^2)$, where R_j^2 was obtained by regressing one regressor on the other. Four robustness checks addressed the risks of short trending series [11; 28]: (i) Newey–West standard errors with one lag [19]; (ii) a model in first differences of the logarithms, which removes common trends; (iii) estimation on the 2017–2024 sub-sample, which avoids the 2015–2016 period preceding the revision of the value added series; (iv) single-regressor models; and (v) a supplementary regional panel regression of ln wage on ln internet density with region fixed effects, then with region and year fixed effects, and standard errors clustered by entity, estimated for all 14 entities and for 13 entities without Tashkent city. All variables were in nominal terms, since no deflators were part of the datasets. Calculations were performed in Python (NumPy, SciPy) and can be replicated from the published datasets and the formulas above.

ANALYSIS AND RESULTS

Table 1 presents the national dynamics of the three indicators in 2015–2024.

Table 1.

Macroeconomic dynamics of digital economy GVA, internet penetration and ICT wages in Uzbekistan, 2015–2024

Year	GVA, billion UZS	GVA growth, %	Internet subscribers per 100	ICT wage, thousand UZS
2015	3,876.3	—	25.8	1,759.7
2016	4,967.7	28.2	29.1	2,042.2
2017	7,044.2	41.8	33.2	2,502.2
2018	8,572.4	21.7	39.1	3,329.6
2019	9,255.0	8.0	46.9	3,968.8
2020	12,006.7	29.7	56.2	4,390.5
2021	18,616.2	55.0	61.8	5,577.2
2022	30,022.5	61.3	68.4	7,560.8
2023	42,896.1	42.9	75.3	10,596.0
2024	60,219.5	40.4	78.7	13,207.2
2024/2015 ratio	15.54	—	3.05	7.51
Average annual growth, %	35.6	—	13.2	25.1

National GVA increased 15.5-fold. Annual growth ranged from 8.0 percent (2019) to 61.3 percent (2022), and the average annual growth rate was 35.6 percent. Internet subscribers per 100 population rose 3.05-fold and the national ICT wage 7.51-fold; the number of subscribers per 100 population was 78.7 in 2024 and 78.6 in 2025.

The annual growth of the national ICT wage ranged from 10.6 percent (2020) to 40.1 percent (2023), and the annual growth of internet subscribers per 100 population ranged from 4.5 percent (2024) to 19.9 percent (2019). GVA exceeded 10,000 billion soums in 2020 (12,006.7) and 30,000 billion soums in 2022 (30,022.5), and the national ICT wage exceeded 10,000 thousand soums in 2023 (10,596.0).

Table 2 contrasts the 14 administrative entities in 2024, ordered by internet density. Figure 1 shows the national trends (panel a) and the regional cross-section (panel b).

Table 2.

Comparative regional disparity matrix in Uzbekistan, 2024: internet subscribers per 100 population and ICT monthly wages

Region	Internet per 100	Rank	Index (national = 100)	ICT wage, th. UZS	Rank	Index (national = 100)
Uzbekistan (national)	78.7	—	100.0	13,207.2	—	100.0
Tashkent city	168.2	1	213.7	14,938.8	1	113.1
Navoi	89.3	2	113.5	7,547.7	12	57.1
Syrdarya	80.3	3	102.0	7,630.4	11	57.8
Bukhara	76.9	4	97.7	8,254.4	6	62.5
Khorezm	76.7	5	97.5	7,826.9	9	59.3
Karakalpakstan	76.3	6	97.0	6,627.0	13	50.2
Fergana	73.7	7	93.6	7,667.2	10	58.1
Namangan	70.7	8	89.8	6,466.2	14	49.0
Jizzakh	69.9	9	88.8	8,282.9	5	62.7
Andijan	69.6	10	88.4	9,024.6	2	68.3
Samarkand	68.7	11	87.3	8,971.9	3	67.9
Tashkent region	65.9	12	83.7	7,830.3	8	59.3
Kashkadarya	63.6	13	80.8	8,605.4	4	65.2
Surkhandarya	61.8	14	78.5	8,045.2	7	60.9

In 2024 Tashkent city recorded 168.2 internet subscribers per 100 population and an average ICT wage of 14,938.8 thousand soums. Among the other 13 entities, internet density ranged from 61.8 (Surkhandarya) to 89.3 (Navoi) and ICT wages from 6,466.2 (Namangan) to 9,024.6 (Andijan) thousand soums. Surkhandarya had the lowest internet density among all entities (61.8) and the 7th-ranked wage (8,045.2 thousand soums, 53.9 percent of the level in Tashkent city). Namangan had 70.7 subscribers per 100 population (rank 8) and the lowest wage (6,466.2 thousand soums, 43.3 percent of the capital's level).

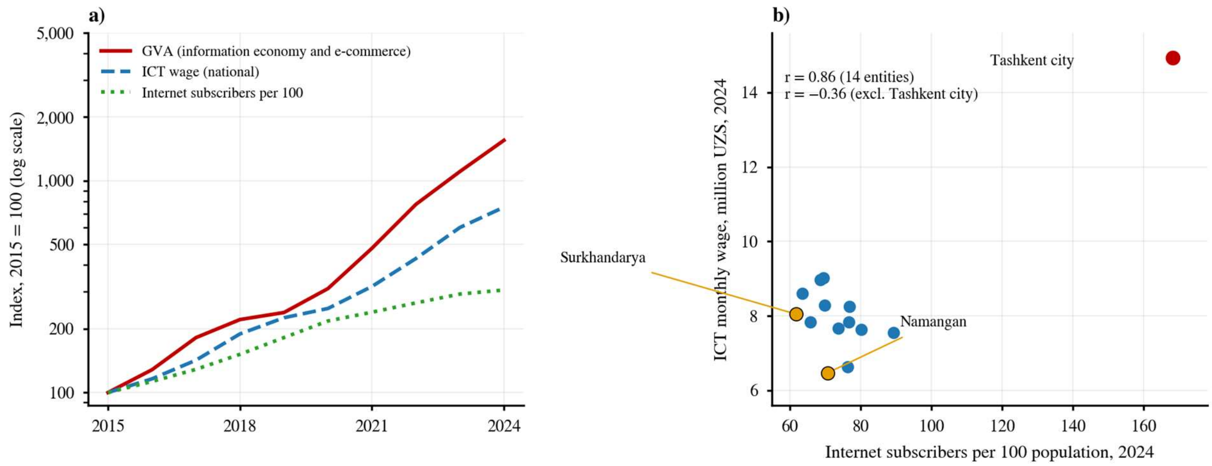

Figure 1. National indices of GVA, internet penetration and ICT wages, 2015 = 100 (a), and regional internet density versus ICT wages in 2024 (b)

Three of the 14 entities exceeded the national internet density in 2024 (Navoi, Syrdarya, Tashkent city), whereas only one entity exceeded the national ICT wage (Tashkent city). The mean internet density of the other 13 entities was 72.6 subscribers per 100 population and their mean ICT wage 7,906.2 thousand soums; the wages of these entities equalled 43.3–60.4 percent of the level in Tashkent city. Between 2015 and 2024 internet density rose by the largest multiple in Tashkent region (×7.0) and by the smallest in Tashkent city (×1.7), while ICT wages rose by ×5.9 in Karakalpakstan and by ×9.5 in Samarkand.

Table 3 reports the estimates of equation (3).

Table 3.

OLS regression results (dependent variable: ln GVA; n = 10, 2015–2024)

Variable	Coefficient	Std. error	t-statistic	p-value	95% confidence interval
Constant	−2.1740	0.5796	−3.75	0.007 ***	[−3.544; −0.804]
ln Internet	−0.3536	0.3785	−0.93	0.381	[−1.249; 0.541]
ln Wage	1.5527	0.2253	6.89	<0.001 ***	[1.020; 2.086]
R^2 / adjusted R^2	0.9896 / 0.9866				
F-statistic (2; 7)	332.75		p <0.001		
Durbin–Watson	1.519				
VIF (ln Internet, ln Wage)	18.57				
Residual standard error	0.1067				

The model explained 98.96 percent of the variation in ln GVA. The coefficient of ln Wage was 1.553 (p <0.001), the coefficient of ln Internet was −0.354 (p = 0.381), and the constant was −2.174 (p = 0.007). The adjusted R^2 was 0.9866, the residual standard error 0.1067 and the Durbin–Watson statistic 1.519. The 95 percent confidence interval was [1.020; 2.086] for the coefficient of ln Wage and [−1.249; 0.541] for that of ln Internet. The overall *F*-test was significant, and the *VIF* was 18.6.

Table 4 reports the Pearson correlation coefficients of the national series and of the regional cross-sections.

Table 4.

Pearson correlation coefficients (with Spearman rank correlations)

Pair	Sample (n)	Pearson r	p-value	Spearman ρ
ln GVA – ln Internet	National, 2015–2024 (10)	0.959	<0.001	1.000
ln GVA – ln Wage	National, 2015–2024 (10)	0.994	<0.001	1.000
ln Internet – ln Wage	National, 2015–2024 (10)	0.973	<0.001	1.000
Internet – Wage	Regions, 2015 (14)	0.963	<0.001	0.458
Internet – Wage	Regions, 2015, excl. Tashkent city (13)	0.299	0.321	0.322
Internet – Wage	Regions, 2020 (14)	0.965	<0.001	0.271
Internet – Wage	Regions, 2020, excl. Tashkent city (13)	0.035	0.910	0.088
Internet – Wage	Regions, 2024 (14)	0.860	<0.001	−0.248
Internet – Wage	Regions, 2024, excl. Tashkent city (13)	−0.363	0.223	−0.560

In the national series, all pairs of logarithmic variables were positively correlated (r from 0.959

to 0.994). In the regional cross-sections, the correlation between internet density and ICT wages was 0.860 in 2024 when Tashkent city was included and −0.363 when it was excluded.

Table 5 reports regional inequality indicators for selected years.

Table 5.

Regional inequality indicators across the 14 administrative entities

Indicator	2015	2018	2020	2022	2024	2025
Internet: CV, all 14 entities	0.787	0.635	0.539	0.353	0.322	0.319
Internet: CV, excl. Tashkent city	0.242	0.204	0.119	0.114	0.099	0.090
Internet: Gini coefficient	0.286	0.237	0.186	0.136	0.123	0.118
Internet: Maximum / minimum	10.60	7.84	4.09	2.86	2.72	2.68
Internet: Tashkent city / mean of other 13	4.77	3.87	3.41	2.45	2.32	2.31
Wage: CV, all 14 entities	0.271	0.322	0.295	0.298	0.232	0.274
Wage: CV, excl. Tashkent city	0.069	0.112	0.065	0.096	0.094	0.194
Wage: Gini coefficient	0.099	0.123	0.103	0.115	0.098	0.127
Wage: Maximum / minimum	2.39	3.11	2.53	2.49	2.31	2.53
Wage: Tashkent city / mean of other 13	2.11	2.30	2.22	2.20	1.89	1.87

Rank positions changed between 2015 and 2024. In internet density, Fergana moved from rank 10 to rank 7, whereas Samarkand moved from rank 7 to rank 11; Tashkent city ranked first in both years. In ICT wages, Samarkand moved from rank 14 to rank 3 and Karakalpakstan from rank 4 to rank 13. The reduction of the CV of internet density was larger in 2015–2020 (from 0.787 to 0.539) than in 2020–2024 (to 0.322), while the CV of ICT wages excluding Tashkent city was 0.065 in 2020 and 0.096 in 2022.

The CV of internet density across the 14 entities fell in every reported year, from 0.787 in 2015 to 0.322 in 2024, and the Gini coefficient from 0.286 to 0.123. The CV of ICT wages was 0.271 in 2015 and 0.232 in 2024, with a maximum of 0.322 among the reported years (2018); excluding Tashkent city it was 0.069 in 2015, 0.094 in 2024 and 0.194 in 2025. The ratio of Tashkent city to the mean of the other entities declined from 4.77 to 2.32 for internet density and from 2.11 to 1.89 for ICT wages.

In the beta-convergence regressions for 2015–2024 the coefficient b was −0.0613 for internet density (p <0.001, R^2 = 0.912) and −0.0315 for ICT wages (p = 0.124, R^2 = 0.186). Excluding Tashkent city, b was −0.0818 for internet density (p <0.001) and −0.1633 for ICT wages (p = 0.0035, R^2 = 0.554). The cross-sectional regression of ln wage on ln internet density in 2024 gave a slope of 0.586 (p = 0.003, R^2 = 0.537) for 14 entities and −0.353 (p = 0.235, R^2 = 0.125) for 13 entities. The average ICT wage in Tashkent region increased from 7,830.3 thousand soums in 2024 to 14,303.8 thousand soums in 2025.

Table 6 presents the robustness checks of the national regression.

Table 6.

Robustness of the national regression (dependent variable: change in or level of ln GVA)

Specification	ln Internet	ln Wage	R²	DW	n
(1) OLS, 2015–2024 (baseline)	−0.354 (0.379)	1.553*** (0.225)	0.990	1.52	10
(2) OLS, Newey–West SE (1 lag)	−0.354 (0.247)	1.553*** (0.134)	0.990	1.52	10
(3) First differences of logs, 2016–2024	−1.653 (0.862)	0.307 (0.515)	0.511	1.61	9
(4) OLS, 2017–2024	−0.314 (0.509)	1.542*** (0.276)	0.983	1.44	8

(5) ln Internet only	2.183*** (0.229)	—	0.919	0.57	10
(6) ln Wage only	—	1.348*** (0.052)	0.988	1.27	10

With Newey–West standard errors, the coefficient of ln Wage remained significant (p <0.001) and that of ln Internet remained insignificant (p = 0.196). In the first-difference model neither slope coefficient was significant at the 5 percent level (p = 0.104 for ln Internet and 0.572 for ln Wage), and R^2 was 0.511. On the 2017–2024 sub-sample, the coefficient of ln Wage was 1.542 (p = 0.003) and that of ln Internet −0.314 (p = 0.564). The single-regressor models gave an elasticity of 2.183 for ln Internet (R^2 = 0.919) and 1.348 for ln Wage (R^2 = 0.988).

Because value added was published only nationally, a regional panel of 14 entities over 2015–2025 could be estimated only for ICT wages and internet density. A regression of ln wage on ln internet density with region fixed effects and standard errors clustered by entity gave a coefficient of 1.486 (p <0.001, within R^2 = 0.839, n = 154), and 1.465 (p <0.001, n = 143) without Tashkent city. When year fixed effects were added, the coefficient was 0.077 (p = 0.445, within R^2 = 0.011) for all entities and 0.0003 (p = 0.998) without Tashkent city.

DISCUSSION

The results portray a digital economy that has expanded far faster than its infrastructure and that is spatially concentrated. The 15.5-fold rise in value added, against a 3.1-fold rise in internet density, suggests that value added grew much faster than connectivity, partly because of prices and partly because of factors other than the number of connected people, and the wage series, which rose 7.5-fold, is the closest companion of value added in the national data. This is consistent with the view that the returns to connectivity depend on complementary assets such as skills [21; 29]. At the same time, the nominal nature of both series and the sharp increase in nominal wages in the early 2020s mean that part of this co-movement reflects inflation and the general rise in the price level, so the estimated wage elasticity of 1.55 should not be read as a real effect.

The regression evidence has to be interpreted with care. The high R^2 of 0.990 arises because both sides of the equation trend strongly, and the well-known spurious-regression problem warns that such fits can occur without any structural link [11]. The wage coefficient remained significant across specifications in levels, yet it lost significance in first differences, which indicates that the relation is mainly a long-run co-trend and not a year-to-year response. The regional panel points the same way: the strong association between wages and internet density under region fixed effects vanished once year effects were included, which suggests that it reflected common nominal trends and not a within-region relation. The negative and insignificant coefficient of ln Internet in the joint model should not be interpreted as a negative effect: internet density is almost collinear with wages (VIF = 18.6), and its single-regressor elasticity was positive and significant. The data thus cannot separate the contribution of telecommunication density from that of the wage level. The hypothesis of the study is therefore neither confirmed nor rejected at the level of causal identification: national-level evidence is consistent with an association between digital capacity, human capital and digital-economy value added, but SME market integration itself was not observed.

The regional analysis shows why the divide is a structural bottleneck for provincial SMEs even when access indicators improve. Internet density converged rapidly: the CV fell from 0.79 to 0.32 and the capital-to-regions ratio from 4.8 to 2.3, and beta convergence was strong, consistent with the convergence of first-level access in a country that started from a low base [22; 25]. Wage indicators behaved differently. The gap between the capital and the other entities narrowed only modestly, dispersion outside the capital increased, and the cross-regional relation between internet density and wages was not positive once the capital was excluded. The divide is therefore mainly a capital-versus-provinces divide, and it persists in the human capital and income dimension, in line with evidence that talent and high-wage occupations concentrate in metropolitan centers [3; 18]. Beta convergence in wages among the entities other than the capital, coexisting with a rise in sigma dispersion, is compatible with the argument that beta convergence is necessary but not sufficient for sigma convergence when idiosyncratic shocks are large [22], and the abrupt jump of wages in Tashkent region in 2025 is an example of such a shock. For provincial SMEs, the practical consequences are logistics friction, the scarcity of affordable local IT developers and lower local demand for online services; these channels were not measured directly and are inferred from the disparity in wages and access.

International comparisons help to place the findings. In China's rural e-commerce initiatives, of which the Taobao villages are the best-known example, the randomized evidence shows that gains accrued mainly on the consumer side and that producer gains were limited [4], which suggests that access alone does not deliver market integration for local producers. Comparisons among European Union member states likewise show that digital gaps follow socio-economic gaps [5], and evidence on the wage effects of the internet indicates that benefits accrue first to places with skilled labor [1; 9]. The Uzbekistan pattern of fast convergence in access and slow convergence in wages fits this literature. Recent policy documents already aim at almost full broadband coverage and at satellite connectivity for remote areas [30], which suggests that the first-level divide will continue to narrow and that policy attention should shift to skills, finance and market access.

Four mechanisms follow from the evidence for bridging the gap and integrating SMEs. First, regional targeted broadband subsidies combined with localized cloud and logistics hubs would reduce the quality gap in access and the delivery friction faced by provincial sellers; subsidies should be tied to outcome indicators such as the share of local firms selling online. Second, tax incentives for regional IT outsourcing companies would offset the wage and talent disparity, because they would allow provinces to retain and attract technical specialists, and they would address the scarcity of local developers. Third, SME digital onboarding platforms, in the form of cooperative digital storefronts and local aggregation of small producers, would pool fixed costs of marketing, payment and logistics and are consistent with the capability-based view of SME digital transformation [16; 20]. Fourth, microfinance and digital literacy vouchers for rural and regional entrepreneurs would address the skills and finance barriers, in line with the role of digital finance in household and occupational outcomes [24]. The mechanisms are complementary and should be sequenced, with the first two addressing the enabling environment and the last two the capacity of firms.

The study has limitations. First, value added is available only at the national level and for a sector that mixes ICT, media and e-commerce, so the regression cannot measure regional SME performance. Second, ten annual observations of trending, nominal series limit the reliability of inference, and the tests of unit roots and cointegration could not be applied meaningfully. Third, the wage series excludes small business workers, which limits its relevance for SME labor markets, and the value added series was revised in 2017. Fourth, unweighted inequality indicators treat entities of unequal size equally, and the internet indicator counts subscribers, so values above 100 per 100 residents in the capital reflect subscriptions of non-residents and multiple subscriptions. Future research should use regional e-commerce and SME sales data, real wages, panel methods on regions and years, and firm-level surveys to identify the effect of infrastructure and skills on SME market integration.

CONCLUSION

This study examined the drivers of the regional digital divide in Uzbekistan and the mechanisms for expanding the market integration of small business entities using official national and regional statistics. The value added of the information economy and e-commerce grew 15.5-fold between 2015 and 2024, but the growth was concentrated: Tashkent city had 168.2 internet subscribers per 100 people in 2024 against 61.8 in Surkhandarya and 70.7 in Namangan, and ICT wages in the capital were far above those in the provinces.

The empirical results answer the research questions as follows. Inequality in internet access across regions declined strongly, whereas inequality in ICT wages narrowed only marginally when the capital was included and widened outside it, so the divide has shifted from access to human capital and income. The regression showed a very close co-movement of national value added with ICT wages and internet density, but it could not separate their effects, and it did not survive as a strong relation in first differences. The hypothesis that bridging telecommunication and human capital gaps accelerates regional SME market integration is therefore consistent with the evidence but is not established, because SME outcomes by region were not observed.

The policy relevance for the National Digital Economy Strategy is that connectivity targets should be complemented by measures aimed at regional talent, finance and market access. Four mechanisms are recommended: targeted regional broadband subsidies with cloud logistics hubs, tax incentives for regional IT outsourcing, cooperative digital storefronts and local aggregation for SMEs, and microfinance with digital literacy vouchers. Their implementation should be accompanied by the collection of regional e-commerce and SME sales statistics so that the effects of these mechanisms can be evaluated with causal methods. Future studies should also use real wages, regional panels and firm-level data to test whether closing the human capital gap is a precondition for the SME market integration that the present evidence can only suggest.

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