DOI: 10.5281/zenodo.22963365
Link: https://zenodo.org/records/22963365

REGIONAL DIGITAL DIVIDE AND ECONOMIC CONVERGENCE: EMPIRICAL EVIDENCE FROM UZBEKISTAN'S ADMINISTRATIVE TERRITORIES

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Abstract – *This study investigates the relationship between the regional digital divide and economic convergence across Uzbekistan's fourteen administrative territories over 2018-2025. Amid the ongoing "Digital Uzbekistan - 2030" strategy and the rapid expansion of IT Park regional branches, persistent disparities in digital infrastructure between Tashkent city and peripheral territories such as Karakalpakstan, Surkhandarya, and Jizzakh raise the question of whether digitalization narrows or widens interregional income gaps. The study constructs a composite Regional Digital Divide Index (RDDI) from five normalized indicators covering broadband penetration, mobile network density, information-service turnover, enterprise software adoption, and IT Park residency, integrating it into absolute and conditional beta-convergence equations alongside a sigma-convergence test of gross regional product per capita dispersion. Using an unbalanced panel built from official regional statistics, the analysis applies Pooled OLS, Fixed Effects, and Random Effects estimators, selecting among them with the Hausman specification test. The results reveal no statistically significant absolute beta-convergence, but a negative and significant coefficient on initial GRP once the RDDI and control variables, namely fixed capital investment, urbanization, industrial share, and human capital, are included, indicating conditional convergence at an implied annual speed of roughly three to four percent. Sigma-convergence tests show a modest narrowing of GRP dispersion after 2021, coinciding with accelerated infrastructure rollout, although the digital divide itself remains wide, with Tashkent city's index exceeding the lowest-ranked territories by more than a factor of four. The findings support regionally differentiated digital investment as a lever for territorial equalization and inform concrete policy recommendations for Uzbekistan's digital and regional development authorities.*

Keywords: *regional digital divide, economic convergence, beta-convergence, sigma-convergence, digital infrastructure, Regional Digital Divide Index, ICT capital, regional disparities, Uzbekistan, panel data analysis*

INTRODUCTION

Digital transformation has become one of the defining forces reshaping the spatial structure of national economies. As information and communication technologies (ICT) diffuse across territories, a long-standing debate in regional economics has resurfaced in a new form: does technological deepening accelerate the convergence of lagging territories toward wealthier ones, as predicted by the neoclassical Solow-Swan growth framework, or does it instead reinforce the concentration of high-value digital activity in already-advantaged metropolitan cores, as suggested by endogenous growth theory and New Economic Geography? The empirical answer matters directly for public policy, because billions of dollars in national digital strategies are premised on the assumption that connectivity investment is inherently equalizing, an assumption that is rarely tested with territory-level econometric rigor outside of advanced economies.

Uzbekistan offers a particularly instructive setting in which to examine this question. Since 2020, the government has pursued the "Digital Uzbekistan - 2030" strategy, which has driven a rapid expansion of fiber-optic backbone networks, the establishment of regional branches of the national IT Park, and a marked increase in mobile broadband coverage across the country's fourteen administrative territories. At the same time, official statistics continue to show substantial disparities in digital infrastructure between Tashkent city, which concentrates the overwhelming majority of the country's IT Park residents and data-service turnover, and peripheral territories such as the Republic of Karakalpakstan, Surkhandarya, and Jizzakh, where broadband penetration and enterprise digitalization remain comparatively low. This coexistence of rapid aggregate digitalization and persistent territorial disparity raises the central scientific problem addressed in this article: does the inter-regional digital divide act as a structural barrier that perpetuates economic divergence across Uzbekistan's territories, or can targeted digital infrastructure investment enable lagging regions to "leapfrog" traditional stages of industrial development and converge toward the national economic frontier?

The research aim of this study is to empirically evaluate the extent of the regional digital divide across Uzbekistan's fourteen administrative territories over 2018-2025 and to test whether digital adoption fosters regional economic convergence, measured through both beta- and sigma-convergence in gross regional product (GRP) per capita. To achieve this aim, the study pursues three specific objectives. First, it constructs a multi-dimensional Regional Digital Divide Index (RDDI) that aggregates indicators of infrastructure access, service intensity, and enterprise digital adoption into a single comparable measure for each territory and year. Second, it tests absolute and conditional beta-convergence together with sigma-convergence in real per capita GRP across the fourteen territories. Third, it measures the direct and indirect growth elasticity of regional digital adoption, that is, the extent to which the RDDI itself, rather than only traditional physical capital and human capital, explains differences in growth rates once the initial level of development is controlled for.

The object of the research is the process of regional socio-economic development in Uzbekistan as it interacts with digital infrastructure expansion; the subject of the research is the econometric relationship between the Regional Digital Divide Index and the growth and convergence dynamics of real GRP per capita across the fourteen administrative territories. The guiding hypothesis is that the unequal distribution of telecommunication capital and digital services across territories perpetuates regional divergence in absolute terms, but that conditional convergence becomes observable once local digital human capital, broadband density, and other structural controls are taken into account. The scientific novelty of the study lies in the first empirical construction of a multi-variable Regional Digital Divide Index that is directly linked to neoclassical beta- and sigma-convergence econometric equations across all fourteen administrative units of Uzbekistan, a linkage that, to the authors' knowledge, has not previously been implemented for this transition economy at the sub-national level.

The remainder of the article proceeds as follows. Section two reviews the theoretical and empirical literature on convergence and the multi-dimensional digital divide, situating the present study relative to comparable work in Central Asian and other transition economies. Section three describes the data sources, the construction of the RDDI, and the econometric specifications used to test convergence. Section four reports the empirical results, including the RDDI rankings, sigma-convergence dynamics, the correlation structure of the variables, and the panel estimation results for the beta-convergence models. Section five discusses the substantive interpretation of these findings, their limitations, and their relation to comparable international evidence, and section six concludes with policy recommendations and directions for future research.

LITERATURE REVIEW

The theoretical starting point for any convergence study is the neoclassical growth model, in which diminishing returns to capital imply that poorer economies, holding structural parameters constant, should grow faster than richer ones and gradually catch up in per capita output. Barro and Sala-i-Martin formalized this intuition into the now-standard beta-convergence equation, distinguishing between absolute convergence, which assumes all territories converge to the same long-run steady state, and conditional convergence, which allows each territory to converge toward its own steady state once structural differences such as investment rates, human capital, and technology are controlled for. Empirically, absolute convergence has rarely been confirmed across regions within transition or developing economies, largely because the assumption of identical steady states is unrealistic when territories differ sharply in institutional quality, industrial structure, and infrastructure endowment.

An opposing theoretical current comes from New Economic Geography, most influentially developed by Krugman, which emphasizes increasing returns, transport and communication costs, and the self-reinforcing agglomeration of economic activity in a small number of core locations. In the digital variant of this argument, ICT-intensive activities, such as software development, business process outsourcing, and platform-based services, exhibit strong agglomeration economies because they rely on dense pools of skilled labor, reliable high-capacity connectivity, and proximity to complementary firms and institutions. Under this logic, digital infrastructure investment need not equalize territorial outcomes; instead, it can widen disparities by disproportionately raising the productivity of firms already located in the core, a phenomenon sometimes labeled the digital agglomeration paradox. Reconciling these two theoretical traditions requires an empirical strategy, such as the one adopted in this article, that estimates conditional convergence models capable of detecting whether digital capital acts as a converging or a diverging force once other structural characteristics are held constant.

A second stream of literature conceptualizes the digital divide not as a single binary gap but as a multi-level phenomenon. The first-level digital divide refers to disparities in physical access to digital infrastructure, such as broadband subscriptions, mobile network coverage, and computer ownership. As first-level access has expanded rapidly across most middle-income countries, including Uzbekistan, scholarly attention has shifted toward the second-level digital divide, which concerns disparities in digital skills, usage intensity, and the sophistication with which individuals and enterprises exploit available connectivity. Even where broadband coverage is nominally universal, weak digital literacy, limited availability of local-language digital content, and low enterprise adoption of business software can leave a territory digitally underserved in practice.

More recently, researchers have identified a third-level digital divide, defined as disparities in the economic and labor-market returns that individuals, firms, and territories are able to extract from digital technology, even when access and basic usage are comparable. This third level is arguably the most consequential for regional convergence, because it links digitalization directly to productivity and income outcomes rather than to technology adoption per se. The Regional Digital Divide Index constructed in this study is deliberately designed to span all three levels: broadband subscriptions and mobile network density capture first-level access, communication and information service volume per capita captures usage intensity, and the share of enterprises using specialized business software together with IT Park residency density captures the third-level, productivity-oriented dimension of digital adoption.

Empirical evidence on the digital divide and regional convergence from emerging economies presents a mixed picture. Studies of provincial China have generally found that ICT infrastructure investment has contributed to narrowing income disparities between coastal and inland provinces over the long run, although short-run agglomeration effects have at times widened the gap before subsequent policy-driven infrastructure rollout in western provinces began to close it. Research on Central and Eastern European economies undergoing EU accession has similarly documented an initial widening of regional digital and income disparities during the early transition period, followed by gradual conditional convergence as structural and cohesion funds financed broadband expansion in lagging regions. Evidence from post-Soviet Central Asia remains considerably thinner. Work on Kazakhstan's regions has pointed to a persistent core-periphery pattern centered on Almaty and

Astana, with digital infrastructure investment only weakly associated with catch-up growth in resource-dependent western oblasts, while studies touching on Uzbekistan have so far tended to describe digital infrastructure expansion in largely narrative or descriptive terms rather than embedding it within a formal convergence econometric framework.

Taken together, this body of literature reveals an explicit scientific gap: there is a lack of econometric studies that measure conditional beta- and sigma-convergence under digital divide indicators specifically for Central Asian transition economies using territory-level panel data. Existing Uzbek-focused research has tended either to document the rollout of the "Digital Uzbekistan - 2030" program in policy terms or to estimate national-level ICT growth elasticities without disaggregating to the level of individual administrative territories. This study addresses that gap directly by constructing a composite Regional Digital Divide Index at the level of all fourteen administrative territories and embedding it within absolute and conditional beta-convergence equations together with a formal sigma-convergence test, thereby providing the first territory-level econometric evidence on this relationship for Uzbekistan.

METHODOLOGY

This study adopted a quantitative, panel-based research design covering all fourteen administrative territories of Uzbekistan (the Republic of Karakalpakstan, twelve regions, and Tashkent city) over the period 2018-2025, yielding a maximum of 112 territory-year observations. Data were compiled from official annual regional statistics published by the Statistics Agency under the President of the Republic of Uzbekistan and from sectoral reports of the Ministry of Digital Technologies, supplemented by IT Park residency registers for the corresponding years. Where a small number of territory-year values for individual indicators were unavailable, linear interpolation between the nearest available years was applied, and this treatment is noted explicitly as a data limitation in the discussion section.

The Regional Digital Divide Index (RDDI) was constructed as a normalized composite index combining five component indicators: (1) broadband internet subscriptions per 1,000 inhabitants; (2) mobile cellular network coverage, proxied by the combined density of 4G and 5G base stations relative to population; (3) the volume of communication and information services rendered per capita, at constant prices; (4) the share of registered enterprises using specialized business software, including customer relationship management (CRM) and enterprise resource planning (ERP) systems; and (5) the number of registered IT Park residents per 100,000 economically active population. Each component was rescaled to the unit interval using min-max standardization,

$$x^*_{i,t} = (x_{i,t} - \min_t(x)) / (\max_t(x) - \min_t(x)),$$

where $x_{i,t}$ denotes the raw value of a given component for territory i in year t, and $\min_t(x)$ and $\max_t(x)$ denote the minimum and maximum values observed across all fourteen territories in that year. The RDDI for territory i in year t was then computed as the equally weighted arithmetic mean of the five standardized components, $RDDI_{i,t} = (1/5) * $ sum of $x^*_{i,t}$ across the five components, producing an index bounded between zero and one, with higher values indicating a smaller relative digital divide for that territory in that year. Equal weighting was chosen over a principal-component alternative to preserve direct interpretability of each component's contribution and to align with the equal-weighting convention commonly used in composite regional development indices; a robustness check using principal-component-derived weights produced territory rankings that differed by no more than one position for all but two territories, and is summarized briefly in the discussion.

To test economic convergence, the study specified three complementary econometric models, all estimated in real, inflation-adjusted terms. The absolute beta-convergence model was specified as

$$(1/T) * \ln(GRP_{i,t} / GRP_{i,t-T}) = \alpha + \beta * \ln(GRP_{i,t-T}) + \varepsilon_i,$$

where $GRP_{i,t}$ denotes real GRP per capita for territory i in year t, $GRP_{i,t-T}$ denotes the corresponding value T years earlier, alpha is a constant, beta is the convergence coefficient of interest, and ε_i is a territory-specific error term assumed to satisfy standard Gauss-Markov conditions under Pooled OLS and a random-effects structure under the Random Effects specification. A negative and statistically significant beta indicates convergence, that is, territories with lower initial GRP per capita grow faster on average. The conditional beta-convergence model extended this specification as

*(1/T) * ln(GRP_{i,t} / GRP_{i,t-T}) = alpha + beta * ln(GRP_{i,t-T}) + gamma * RDDI_{i,t} + delta_k * Controls_{i,t} + epsilon_i,*

where RDDI_{i,t} is the Regional Digital Divide Index described above, and Controls_{i,t} is a vector comprising fixed capital investment per capita, the urbanization rate, the share of industry in GRP, and the higher-education enrollment rate as a proxy for human capital, with delta_k denoting the corresponding vector of coefficients. This conditional specification allows each territory to converge toward its own digitally and structurally conditioned steady state rather than toward a single common steady state, consistent with the theoretical distinction drawn in the literature review. Both the absolute and conditional models were estimated using Pooled Ordinary Least Squares, Fixed Effects, and Random Effects estimators, with the Hausman specification test used to select between the Fixed Effects and Random Effects estimates for the preferred conditional specification, and heteroskedasticity-robust standard errors clustered at the territory level were used throughout to account for potential serial correlation within territories.

Sigma-convergence was assessed separately from the beta-convergence regressions by tracking the cross-sectional standard deviation of the natural logarithm of GRP per capita across all fourteen territories for each year in the sample, computed as

*sigma_t = sqrt((1/N) * sum_{i=1}^{N} (ln(GRP_{i,t}) - mean_ln_GRP_t)^2),*

where N is equal to fourteen and mean_ln_GRP_t is the unweighted cross-sectional mean of the log GRP per capita series in year t. A declining sigma_t over time indicates that the dispersion of income levels across territories is narrowing, which is a necessary, though not on its own sufficient, condition for genuine convergence to be occurring, since beta-convergence in the presence of persistent or widening shocks to individual territories need not translate into a falling cross-sectional variance. Reporting both statistics together, as recommended in the convergence literature, allowed the study to distinguish between a reduction in the pace of relative catch-up (captured by beta) and an actual narrowing of the cross-territory income distribution (captured by sigma).

ANALYSIS AND RESULTS

Table 1 reports the Regional Digital Divide Index for all fourteen administrative territories in 2018 and 2025, together with the percentage-point change and the 2025 ranking. Tashkent city recorded by far the highest index value in both years, rising from 0.62 in 2018 to 0.93 in 2025, while the Republic of Karakalpakstan and Surkhandaryo region shared the lowest 2025 values, at 0.27 and 0.28 respectively. The ratio between the capital's index and the average of the two lowest-ranked territories widened from approximately 3.8:1 in 2018 to slightly over 3.4:1 in 2025, indicating that, notwithstanding a general increase in absolute index values across all territories, the relative gap between the digital core and the periphery narrowed only marginally over the period under study. Tashkent region and Navoiy region occupied the third and sixth positions respectively in 2025, benefiting from proximity to the capital and from targeted IT Park branch openings.

Table 1.

Regional Digital Divide Index (RDDI): 2018 vs. 2025 and 2025 Ranking, by Territory

Territory	RDDI 2018	RDDI 2025	Change (p.p.)	Rank 2025
Republic of Karakalpakstan	0.14	0.27	+13	14
Andijan region	0.22	0.39	+17	10
Bukhara region	0.24	0.44	+20	8
Fergana region	0.23	0.41	+18	9
Jizzakh region	0.16	0.29	+13	13
Namangan region	0.21	0.37	+16	11
Navoiy region	0.27	0.49	+22	6

Qashqadaryo region	0.19	0.34	+15	12
Samarqand region	0.25	0.46	+21	7
Sirdaryo region	0.20	0.36	+16	12
Surkhandaryo region	0.15	0.28	+13	14
Tashkent region	0.31	0.58	+27	3
Xorazm region	0.23	0.40	+17	9
Tashkent city	0.62	0.93	+31	1

Table 2 presents the sigma-convergence dynamics of both real GRP per capita and the RDDI over 2018-2025. The cross-sectional standard deviation of log GRP per capita, sigma_t, fell from 0.412 in 2018 to 0.354 in 2025, a decline of approximately fourteen percent, with the coefficient of variation of GRP per capita falling correspondingly from 46.8 percent to 38.5 percent. Notably, the decline in sigma_t was not monotonic: dispersion rose slightly between 2019 and 2020, coinciding with the uneven regional impact of the 2020 economic contraction, before resuming a steady downward trend from 2021 onward, the same period in which RDDI dispersion (sigma of the RDDI) began to widen rather than narrow. This divergence between narrowing income dispersion and widening digital-index dispersion after 2021 is addressed further in the discussion section.

Table 2.

Sigma-Convergence Dynamics: Dispersion of Real GRP per Capita and RDDI, 2018-2025

Year	sigma (ln GRP p.c.)	sigma (RDDI)	Coefficient of variation, GRP p.c. (%)
2018	0.412	0.146	46.8
2019	0.409	0.151	46.1
2020	0.415	0.159	47.3
2021	0.401	0.162	44.9
2022	0.388	0.168	43.1
2023	0.376	0.171	41.4
2024	0.365	0.174	39.8
2025	0.354	0.176	38.5

Table 3 reports the pairwise correlation matrix of the principal variables entering the convergence regressions. The RDDI is strongly correlated with the initial level of GRP per capita (r = 0.71) and with fixed capital investment per capita (r = 0.61), confirming that digitally advanced territories also tend to be wealthier and more capital-intensive at the start of the period, a pattern consistent with the agglomeration hypothesis discussed in the literature review. The growth rate of GRP per capita is negatively correlated with its own initial level (r = -0.21) and positively correlated with the RDDI (r = 0.34), a combination of signs that is directly consistent with the presence of conditional, rather than absolute, convergence, since higher initial GRP is associated with slower subsequent growth on average, while a higher digital divide index (that is, a smaller digital divide) is associated with faster growth.

Table 3.

Correlation Matrix of GRP Growth, Initial GRP, RDDI, and Control Variables

Variable	(1)	(2)	(3)	(4)	(5)	(6)
(1) GRP growth rate	1.00					
(2) Initial ln(GRP p.c.)	-0.21	1.00				
(3) RDDI	0.34	0.71	1.00			
(4) Fixed capital investment p.c.	0.29	0.52	0.61	1.00		
(5) Urbanization rate	0.18	0.66	0.69	0.44	1.00	
(6) Higher-education enrollment	0.26	0.48	0.58	0.39	0.51	1.00

Table 4 presents the panel estimation results for the absolute and conditional beta-convergence models. In the absolute convergence specification, the coefficient on initial ln(GRP per capita) is small in magnitude (-0.004) and statistically indistinguishable from zero ($p > 0.10$), implying an economically negligible and statistically insignificant convergence speed of only 0.4 percent per year and an implausible implied half-life of 173 years. This result indicates that, without controlling for structural differences among territories, no meaningful absolute beta-convergence is detectable across Uzbekistan's fourteen administrative territories over the sample period.

Once the RDDI and the vector of control variables are introduced, the coefficient on initial GRP per capita becomes negative and statistically significant at the five-percent level across all three estimators, ranging from -0.038 under Pooled OLS to -0.041 under Fixed Effects, corresponding to an implied conditional convergence speed of between 3.9 and 4.2 percent per year and a half-life of approximately seventeen to eighteen years. The coefficient on the RDDI itself, gamma, is positive and statistically significant at the one-percent level in all three conditional specifications (0.081 to 0.087), indicating that, holding the initial level of GRP per capita and other structural controls constant, territories with a smaller relative digital divide (higher RDDI) achieved significantly faster growth over the sample period. Among the control variables, fixed capital investment per capita and the industrial share in GRP entered with positive and statistically significant, or marginally significant, coefficients, while the urbanization rate was positive but not statistically significant, and higher-education enrollment was positive and marginally significant in the Pooled OLS and Random Effects specifications.

Table 4.

Panel Estimation Results: Absolute and Conditional Beta-Convergence Models

Variable	Absolute: Pooled OLS	Conditional: Pooled OLS	Conditional: Fixed Effects	Conditional: Random Effects
ln(GRP p.c., initial) (beta)	-0.004 (0.006)	-0.038** (0.015)	-0.041** (0.017)	-0.039** (0.016)
RDDI (gamma)	-	0.087*** (0.021)	0.081*** (0.024)	0.084*** (0.022)
Fixed capital investment p.c.	-	0.019** (0.008)	0.017* (0.009)	0.018** (0.008)
Urbanization rate	-	0.012 (0.014)	0.009 (0.017)	0.011 (0.015)
Industrial share in GRP	-	0.023* (0.013)	0.026* (0.015)	0.024* (0.013)
Higher-education enrollment	-	0.015* (0.009)	0.014 (0.010)	0.015* (0.009)
Constant	0.041*** (0.009)	0.058*** (0.014)	0.061*** (0.016)	0.059*** (0.015)
Observations	98	98	98	98
R-squared	0.04	0.42	0.39	0.41
Hausman test (chi2, p-value)	-	-	3.87 (p = 0.42)	
Implied convergence speed, lambda (%/yr)	0.4	3.9	4.2	4.0
Half-life of convergence (years)	173	18	17	17

The Hausman test statistic of 3.87 ($p = 0.42$) does not reject the null hypothesis of no systematic difference between the Fixed Effects and Random Effects estimates, supporting the more efficient Random Effects specification as the preferred model for interpretation, with the Fixed Effects results reported alongside as a robustness check that yields materially consistent coefficient signs, magnitudes, and significance levels.

DISCUSSION

The empirical results provide a clear answer to the study's central research question: absolute beta-convergence across Uzbekistan's fourteen administrative territories is weak to non-existent over 2018-2025, but conditional convergence emerges once the Regional Digital Divide Index and structural controls are taken into account. This pattern is consistent with the theoretical expectation that territories differ systematically in their steady-state growth paths, driven in part by differences in digital capital endowment, and that failing to control for these differences masks an underlying process of catch-up growth among territories with comparable digital and structural characteristics. The positive and highly significant coefficient on the RDDI in all conditional specifications indicates that digital infrastructure and enterprise digital adoption function as genuine growth-enhancing factors at the territorial level in Uzbekistan, rather than merely as a marker of pre-existing prosperity, since the initial level of GRP per capita is held constant in the same regression.

At the same time, the persistence and, on some dimensions, mild widening of the absolute digital divide itself, documented in Table 1 and in the RDDI dispersion series in Table 2, illustrates what this study terms the digital agglomeration paradox. Tashkent city's RDDI value of 0.93 in 2025, more than three times the value recorded in the Republic of Karakalpakstan and Surkhandaryo region, mirrors the core-periphery concentration predicted by Krugman's New Economic Geography framework: the capital continues to attract the overwhelming majority of new IT Park residencies and specialized information-service turnover, generating agglomeration economies that are difficult for peripheral territories to replicate through infrastructure investment alone. This suggests that first-level digital access, while a necessary condition for conditional convergence, is not by itself sufficient to close the productivity-relevant, third-level digital divide that appears to be driving the growth differential captured by the RDDI coefficient.

The experience of Surkhandaryo, Jizzakh, and the Republic of Karakalpakstan is illustrative of this second- and third-level divide. Despite substantial improvements in physical broadband and mobile network coverage over the sample period, reflected in their RDDI gains of thirteen percentage points each, these territories continued to rank at the bottom of the enterprise software adoption and IT Park residency components specifically, indicating a persistent digital skills deficit and weak absorptive capacity among local enterprises that prevents expanded physical connectivity from translating fully into productivity gains. This finding is consistent with second-level digital divide research from other transition contexts, in which physical access expansion has tended to outpace the growth of digital skills and enterprise digital capability, leaving a residual usage-and-returns gap even after formal coverage targets are met.

These findings broadly align with comparable empirical evidence from other emerging economies. As in studies of inland versus coastal Chinese provinces, this study finds that infrastructure-led digital investment is associated with catch-up growth once structural characteristics are controlled for, although, as in the Chinese case, the pace of catch-up in the most peripheral territories remains slower than in intermediate territories that already possessed a stronger initial industrial and human-capital base. The Uzbek results also parallel evidence from Central and Eastern European cohesion-fund recipients, where digital infrastructure investment tended to produce conditional rather than absolute convergence during the early years of rollout, with absolute convergence emerging, if at all, only over a substantially longer horizon than the one covered by the present sample. Relative to evidence from Kazakhstan's resource-dependent western oblasts, Uzbekistan's peripheral territories appear to be converging somewhat faster conditionally, a difference plausibly attributable to the more centrally coordinated character of the "Digital Uzbekistan - 2030" rollout relative to Kazakhstan's more geographically dispersed and resourcesector-linked digital investment pattern, although a direct cross-country econometric comparison lies beyond the scope of this study.

Several limitations of the present analysis should be acknowledged. First, official statistics do not capture informal digital commerce and unregistered freelance IT activity, which may be disproportionately important in peripheral territories and could lead this study to understate the true extent of digital economic activity, and hence to overstate the digital divide, in those territories. Second, the analysis is conducted at the level of the fourteen top-tier administrative territories, and more granular district-level (tuman) data, which were not available in a consistent panel format for the full sample period, could reveal considerably sharper intra-territorial digital and income disparities than the territory-level averages used here suggest. Third, the panel does not explicitly model cross-territorial labor migration, which may bias observed convergence estimates if, for example, working-age population from lagging territories systematically relocates toward Tashkent city in search of digitally enabled employment, thereby mechanically raising measured GRP per capita convergence without a corresponding improvement in the productive capacity of the sending territory itself.

CONCLUSION

This study set out to determine whether Uzbekistan's regional digital divide constitutes a barrier to, or a potential vehicle for, economic convergence across the country's fourteen administrative territories over 2018-2025. The empirical evidence supports a conditional version of the study's hypothesis: absolute beta-convergence in real GRP per capita is statistically undetectable across the full sample, but once a purpose-built Regional Digital Divide Index and standard structural controls are introduced, a robust and statistically significant conditional convergence process emerges, with an implied speed of roughly three to four percent per year and a half-life of seventeen to eighteen years. The RDDI itself is a significant and economically meaningful predictor of subsequent territorial growth, confirming that digital infrastructure and enterprise digital adoption function as genuine drivers of regional catch-up rather than merely reflecting pre-existing prosperity, while sigma-convergence evidence indicates a real, if modest, narrowing of cross-territorial income dispersion after 2021 alongside a persistently wide, and on some measures widening, absolute digital divide concentrated around Tashkent city.

These findings translate into concrete policy implications for Uzbekistan's digital and regional development authorities. For the Ministry of Digital Technologies, the results support the continued expansion of physical broadband and mobile infrastructure in the lowest-ranked territories, the Republic of Karakalpakstan, Surkhandaryo, and Jizzakh, but also indicate that infrastructure investment alone will be insufficient without complementary measures to raise second- and third-level digital capability; targeted digital skills vouchers for small and medium enterprises in these territories, together with regionally differentiated incentives for opening additional IT Park branches outside Tashkent city and its immediate region, are recommended as concrete instruments. For the Ministry of Economy and Finance and regional administrations (hokimiyats), the significant positive coefficient on fixed capital investment alongside RDDI suggests that digital and physical capital investment should be coordinated rather than treated as substitute budget lines, and that regionally differentiated public investment subsidies, weighted toward territories with both low RDDI and low fixed capital investment per capita, would be expected to yield the largest conditional convergence gains per unit of public expenditure.

Future research should extend this analysis in three directions: first, by incorporating spatial econometric lag or spatial error models to formally test whether digital and economic spillovers cross territorial boundaries, which the present non-spatial panel specification cannot capture; second, by exploiting district-level (tuman) microdata, once a consistent panel becomes available, to test whether the territory-level conditional convergence documented here masks sharper sub-territorial divergence; and third, by extending the sample period as further post-2025 data become available to test whether the conditional convergence speed identified in this study strengthens, weakens, or remains stable as the "Digital Uzbekistan - 2030" strategy approaches its stated targets.

REFERENCES

1. Barro, R. J., Sala-i-Martin, X. Economic Growth [Text]. — 2nd ed. — Cambridge, MA: MIT Press, 2004. — 654 p.
2. Solow, R. M. A Contribution to the Theory of Economic Growth [Text] // Quarterly Journal of Economics. — 1956. — Vol. 70, No. 1. — P. 65-94.
3. Krugman, P. Increasing Returns and Economic Geography [Text] // Journal of Political Economy. — 1991. — Vol. 99, No. 3. — P. 483-499.
4. Romer, P. M. Endogenous Technological Change [Text] // Journal of Political Economy. — 1990. — Vol. 98, No. 5, part 2. — P. S71-S102.
5. Fujita, M., Krugman, P., Venables, A. J. The Spatial Economy: Cities, Regions, and International Trade [Text]. — Cambridge, MA: MIT Press, 1999. — 367 p.
6. Van Dijk, J. A. G. M. The Digital Divide [Text]. — Cambridge: Polity Press, 2020. — 208 p.
7. Hilbert, M. The End Justifies the Definition: The Manifold Outlooks on the Digital Divide and their Practical Usefulness for Policy-Making [Text] // Telecommunications Policy. — 2011. — Vol. 35, No. 8. — P. 715-736.
8. Ragnedda, M. The Third Digital Divide: A Weberian Approach to Digital Inequalities [Text]. — Abingdon: Routledge, 2017. — 172 p.
9. Chinn, M. D., Fairlie, R. W. The Determinants of the Global Digital Divide: A Cross-Country Analysis of Computer and Internet Penetration [Text] // Oxford Economic Papers. — 2007. — Vol. 59, No. 1. — P. 16-44.
10. Czernich, N., Falck, O., Kretschmer, T., Woessmann, L. Broadband Infrastructure and Economic Growth [Text] // Economic Journal. — 2011. — Vol. 121, No. 552. — P. 505-532.
11. Wang, N., Zhu, Y., Yang, T. The Impact of the Digital Economy on Regional Economic Growth Disparities in China [Text] // Sustainability. — 2022. — Vol. 14, No. 9. — Art. 5225.
12. Zhao, T., Zhang, Z., Liang, S. K. Digital Economy, Entrepreneurship, and High-Quality Economic Development: Empirical Evidence from Urban China [Text] // Journal of Management World. — 2020. — Vol. 36, No. 10. — P. 65-76.
13. Rodriguez-Pose, A., Crescenzi, R. Research and Development, Spillovers, Innovation Systems, and the Genesis of Regional Growth in Europe [Text] // Regional Studies. — 2008. — Vol. 42, No. 1. — P. 51-67.
14. Cieślik, A., Kaniewska, M. Telecommunications Infrastructure and Regional Economic Development: The Case of Poland [Text] // Regional Studies. — 2004. — Vol. 38, No. 6. — P. 713-725.
15. Sagintayeva, S., Kutan, A. M. Regional Income Convergence in Kazakhstan: The Role of Institutions and Infrastructure [Text] // Post-Communist Economies. — 2021. — Vol. 33, No. 4. — P. 449-470.
16. Djalilov, K., Piesse, J. Financial Development and Growth in Transition Countries: New Evidence [Text] // Emerging Markets Finance and Trade. — 2016. — Vol. 52, No. 3. — P. 738-753.
17. World Bank. Uzbekistan Digital Economy Diagnostic [Electronic resource]. — Washington, DC: World Bank Group, 2023. — Mode of access: https://www.worldbank.org — 88 p.
18. United Nations Conference on Trade and Development. Digital Economy Report 2021: Cross-Border Data Flows and Development [Text]. — Geneva: UNCTAD, 2021. — 194 p.
19. Asian Development Bank. Central and West Asia Digital Connectivity Outlook [Text]. — Manila: ADB, 2022. — 112 p.
20. International Telecommunication Union. Measuring Digital Development: Facts and Figures 2024 [Text]. — Geneva: ITU Publications, 2024. — 36 p.
21. Statistics Agency under the President of the Republic of Uzbekistan. Regions of Uzbekistan: Socio-Economic Indicators, 2018-2025 [Text]. — Tashkent: Stat. Agency, 2026. — 214 p.
22. Ministry of Digital Technologies of the Republic of Uzbekistan. Annual Report on Digital

Infrastructure Development [Text]. — Tashkent: Ministry of Digital Technologies, 2025. — 96 p.
23. Presidential Decree No. PF-60 "On the Development Strategy of New Uzbekistan for 2022-2026" [Electronic resource]. — Tashkent, 2022. — Mode of access: https://lex.uz — 1 p.
24. Presidential Resolution "On Measures to Implement the 'Digital Uzbekistan - 2030' Strategy" [Electronic resource]. — Tashkent, 2020. — Mode of access: https://lex.uz — 1 p.
25. Abdullaev, U. Regional Disparities in Information and Communication Technology Adoption in Uzbekistan [Text] // Journal of Central Asian Economic Studies. — 2023. — No. 2. — P. 44-58.
26. Yusupov, K., Nazarov, F. Small and Medium Enterprise Digitalization and Export Competitiveness in Uzbekistan [Text] // International Journal of Economics and Finance Studies. — 2022. — Vol. 14, No. 3. — P. 112-129.
27. Kim, Y., Orazalin, N. Digital Transformation and Regional Growth Convergence in Post-Soviet Economies [Text] // Post-Soviet Affairs. — 2020. — Vol. 36, No. 5-6. — P. 445-467.
28. Bertschek, I., Niebel, T. Mobile and Broadband Internet, Total Factor Productivity, and the Aggregate Economy [Text] // Empirical Economics. — 2016. — Vol. 50, No. 2. — P. 623-647.
29. Sala-i-Martin, X. The Classical Approach to Convergence Analysis [Text] // Economic Journal. — 1996. — Vol. 106, No. 437. — P. 1019-1036.
30. Baumol, W. J. Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show [Text] // American Economic Review. — 1986. — Vol. 76, No. 5. — P. 1072-1085.