ISSN: 2029-4913 / eISSN: 2029-4921

Article in press

TECHNOLOGICAL and ECONOMIC DEVELOPMENT of ECONOMY

https://doi.org/10.3846/tede.2026.26059

HOW THE DIGITAL ECONOMY NARROWS REGIONAL SOCIAL DISPARITIES: MECHANISMS AND EVIDENCE FROM CHINESE CITIES

Bowen LI [1,2], Yiran CHENG [3]

[1] *School of Business Administration, Northeastern University, 110167 Shenyang, China*
[2] *School of Economics, Northeastern University at Qinhuangdao, 066004 Qinhuangdao, China*
[3] *School of Economics, Lanzhou University, 730000 Lanzhou, China*

Article History:

- received 11 May 2025
- accepted 26 January 2026
- first published online 8 June 2026

Abstract. The widening gap in social development across regions poses a critical challenge to achieving inclusive growth in emerging economies. This study investigates whether and how the digital economy can act as an equalizing force, promoting shared prosperity. Using a balanced panel of 268 Chinese cities from 2003 to 2020, we construct a multidimensional digital economy index through the entropy method and apply an Instrumental-Variable (IV) approach based on historical postal network density to address endogeneity. The results show that digitalization significantly reduces regional social disparities – particularly in western cities – by strengthening fintech inclusion, improving rural living conditions, and enhancing urban innovation capacity. Robustness tests with alternative indicators, subsample analyses, and policy-control variables confirm the stability of the findings. Methodologically, this paper adds value by integrating entropy-weighted digital measurement with IV-based causal inference; conceptually, it advances the understanding of digital transformation as both a driver of productivity and a social equalizer. Policy-wise, the findings suggest that targeted investment in digital infrastructure, inclusive finance, and human-capital development is essential for aligning digital strategies with sustainable and regionally balanced growth.

Keywords: digital economy, regional inequality, social development, common prosperity, inclusive growth.

JEL Classification: O18, O33, R12, R58.

Corresponding author. E-mail: ***bowenli@126.com***

1. Introduction

In the ongoing endeavor to build a modern socialist nation, achieving shared prosperity has become a defining goal of this new era (Yu, 2024). The essence of shared prosperity lies in integrating scientific development with social equity, ensuring that the benefits of economic growth are distributed broadly and fairly. It emphasizes not only rational income distribution but also the coordinated advancement of regions and social groups based on productivity improvements. China's experience demonstrates that institutional reform in the distribution system serves as the fundamental driver of shared prosperity (Liu et al., 2020). While progress has been substantial, challenges remain: the gap between urban and rural development persists, regional collaboration needs to be reinforced, and disparities in living standards among social strata remain notable (Bin Abu Sofian et al., 2024).

These persistent gaps highlight the need to explore new drivers of equitable development that can strike a balance between efficiency and inclusion.

From an academic perspective, the pursuit of shared prosperity raises a crucial research question: how can economic modernization reconcile growth efficiency with social inclusiveness? This question is increasingly examined through the lens of technological change, as digital transformation reshapes production, labor, and welfare systems worldwide. Consequently, the digital economy has emerged as a key testing ground for the theory and practice of inclusive development. Practically, the issue is vital for countries seeking to align digital strategies with the goals of equity and sustainability.

The digital economy represents a transformative paradigm that succeeds the agricultural and industrial eras (Li & Li, 2022; Li & Hu, 2025; Zhou & Li, 2023). Built on data as a new production factor and networks as key infrastructure, it integrates Information and Communication Technologies (ICTs) into all dimensions of production and life. This transition enables a new balance between efficiency and equity, transforming how resources, capital, and knowledge circulate in the economy and reshaping patterns of urban expansion and spatial organization (Li & Hu, 2025). Coordinated advances in technology, business models, and institutional innovation jointly accelerate the digital transformation of society and the economy (Pan et al., 2022).

Nevertheless, despite its transformative potential, the conceptualization of how the digital economy contributes to social equity remains incomplete. While it enhances growth and innovation (Li & Zhou, 2024; Li, 2025; Li et al., 2025b; Zong & Guan, 2025), the effects of this approach on regional social disparities remain ambiguous.

Clarifying these differential effects is essential for understanding whether digitalization functions as an equalizer or a divider across regions.

Existing research offers mixed evidence. In the European Union, digitalization has improved productivity and cohesion, but persistent gaps in digital literacy and institutional quality have slowed convergence (Crescenzi et al., 2022; Kovac et al., 2024). In Latin America and Africa, digital adoption initially widened inequality due to uneven access to infrastructure and skills, but it gradually fostered inclusion as institutions matured (Hilbert, 2016; Osei-Assibey et al., 2023).

These international experiences suggest that the inclusiveness of digital transformation is contingent rather than automatic – dependent on institutional capacity, policy design, and regional adaptability. Recent empirical evidence from China further shows that digital infrastructure may narrow regional economic and environmental gaps under coordinated policy frameworks (Li, 2025; Li & Yang, 2025; Li et al., 2025a).

Hence, the core conceptual gap lies in understanding under what institutional and regional conditions digitalization reduces rather than reinforces inequality.

This knowledge gap forms the theoretical foundation for our empirical investigation.

In recent years, this issue has become increasingly timely. The acceleration of digital infrastructure construction, Artificial Intelligence (AI) applications, data-governance reforms, and digital public services has reshaped regional development dynamics in China since 2015. The national push for initiatives such as Broadband China, East Data, West Computing reflects the strategic importance of digital inclusiveness in achieving shared prosperity. Meanwhile, new technologies – such as distributed computing, blockchain-based governance, and rural fintech platforms – have simultaneously created opportunities for growth and new risks of inequality.

This duality – between empowerment and exclusion – highlights the urgency of systematically evaluating how digitalization affects regional social development.

In comparison to prior research, this study makes several novel contributions. First, while existing studies have primarily examined the digital economy's role in productivity and innovation (Crescenzi et al., 2022; Li & Zhou, 2024; Zong & Guan, 2025), relatively few have explored its social development implications and regional heterogeneity. Second, most cross-national or macro-level studies overlook the micro-regional mechanisms through which digitalization affects local welfare. This paper addresses that gap by employing city-level panel data (268 cities, 2003–2020) and identifying three specific mechanisms – fintech development, rural living improvement, and urban innovation. Third, China's large-scale, state-led digital transformation provides a distinct case to test whether coordinated national strategies can mitigate regional disparities, contrasting with the more market-driven approaches of the EU or Latin America.

Together, these innovations make this study both timely and distinctive within the literature on digital transformation and regional equity.

Against this global backdrop, China provides a unique setting to examine whether large-scale, state-led digitalization can reconcile growth with equity. National strategies such as the Broadband China Initiative and the "East Digital, West Computing" project have emphasized the balanced deployment of digital infrastructure and the redistribution of digital resources across regions. However, empirical evidence on whether these initiatives truly narrow the regional social development gap remains limited.

Addressing this empirical vacuum, our study poses two fundamental questions: Does digital transformation reduce regional disparities in social development? If so, through what mechanisms does this process contribute to the broader goal of shared prosperity?

The marginal contributions are threefold. First, using panel data from 268 prefecture-level cities between 2003 and 2020, this paper provides a comprehensive empirical assessment of how digital-economy development affects regional social disparities in China. Second, by identifying the channels through which digitalization operates – financial technology advancement, rural livelihood improvement, and urban innovation – the paper conceptualizes the mechanisms through which the digital economy promotes social convergence. Third, it extends the analysis to the macro level, showing how the digital economy supports shared prosperity through its linkage effects on inclusive growth and regional coordination.

By situating China's experience within the global debate on the digital divide, this study contributes to a more integrated theoretical and policy understanding of digital transformation as a pathway toward inclusive and sustainable development.

2. Theoretical analysis and research hypothesis

A new era of technological and industrial transformation is underway, with the digital economy becoming a crucial pathway for fostering inclusive and sustainable development. Digital technologies reduce information asymmetry (Mao, 2026), enhance the efficiency of public services, and enable the equitable allocation of resources across regions. Through mechanisms such as e-government and digital governance, underdeveloped areas can access public services and policy support more effectively, improving transparency and administrative efficiency. At the same time, by promoting trade, talent flow, and industrial collaboration between eastern and western regions, the digital economy helps foster regional complementarity and coordinated growth (Xiong et al., 2025).

Nevertheless, the benefits of digitalization are not automatically inclusive. International studies reveal that the digital economy may also exacerbate inequality if gaps in infrastructure, education, and institutional quality persist (Crescenzi et al., 2022; Hilbert, 2016). This phenomenon – often referred to as the digital divide – suggests that digital transformation reduces disparities only when barriers to access and capability are effectively mitigated. Hence, this study posits the following core hypothesis:

H1: *The digital economy tends to narrow regional social development gaps to the extent that differences in access to digital infrastructure and technology adoption are mitigated.*

Digital transformation also affects development through multiple mechanisms.

First, financial technology (fintech) expands the coverage and efficiency of financial services, allowing inclusive access to credit, insurance, and investment. By integrating big data, AI, and blockchain, fintech enhances risk assessment, reduces transaction costs, and supports SMEs and rural users who were previously excluded from traditional finance (Jia & Kanagaretnam, 2025; Li & Fan, 2025; Zhu & Guo, 2024). However, regional imbalances in fintech adoption may also create new divides if financial innovation clusters only in advanced cities.

H2a: *The digital economy reduces regional social development disparities by enhancing fintech inclusion, provided that access to digital financial services is broad-based rather than concentrated in developed regions.*

Second, the digital economy improves rural living standards through digital agriculture, online education, e-commerce, and digital public services (Ye, 2025; Zhan et al., 2025). Digital inclusion enables rural residents to acquire new skills, access non-agricultural employment opportunities, and diversify their income sources (Li & Li, 2022; Wang & Zhang, 2025). However, unequal broadband coverage and digital literacy may limit these benefits.

H2b: *The digital economy improves rural living standards and narrows urban-rural gaps to the extent that rural areas gain equitable access to digital infrastructure and capabilities.*

Third, urban innovation constitutes another channel. The diffusion of digital technologies accelerates knowledge spillovers, entrepreneurship, and technological upgrading, enhancing productivity and sustainability (Li, 2025; Liu & Wang, 2025; Ye, 2025). Urban innovation can also generate spatial spillovers that promote growth in surrounding regions. However, excessive spatial concentration of innovation could reinforce metropolitan advantages and interregional inequality.

H2c: *The digital economy promotes urban innovation and contributes to social convergence as long as innovation diffusion and spillovers extend beyond core cities.*

Finally, by integrating these mechanisms, digital transformation can advance shared prosperity – that is, growth that is both efficient and equitable. Digital platforms can improve productivity, enhance public service provision, and diversify regional economies (Luo et al., 2023). However, the inclusiveness of this process depends on institutional design and digital governance.

H3: *The digital economy contributes to shared prosperity if institutional and policy frameworks effectively bridge the digital divide and ensure inclusive participation in digitalization.*

3. Research and data methodology

3.1. Model construction

To examine the causal relationship between digital economy development and regional social development, this study follows a theory-driven model-building approach grounded in institutional economics and regional convergence theory.

According to the digital-inclusiveness framework (Acemoglu et al., 2019; North, 1990), digital transformation influences social development through productivity enhancement, financial inclusion, and information diffusion. Empirically, recent studies such as Zhang and Qu (2024), Li and Li (2022), and Ye (2025) have adopted panel-data fixed-effects models to quantify how digitalization affects economic and social outcomes while accounting for unobserved heterogeneity.

Building upon this foundation, we construct a two-way fixed-effects model as follows:

$$Scidevelopment_{it} = \alpha_0 + \alpha_1 Digeconomy_{it} + \alpha_2 Control_{it} + \delta_{1t} + \varphi_{1i} + \varepsilon_{1it}, \quad (1)$$

where, i represents a city individual, and t is the year. The core explanatory variable $Digeconomy_{it}$ represents the level of digital economic development in the i city in the year t; the interpreted variable $Scidevelopment_{it}$ represents the degree of social development in the i city in the year t; and $Control_{it}$ describes the relevant control variables at the corresponding urban level in the city i in the year t. The urban fixed effect of the model (1) is estimated by φ_{1i}, and the time fixed effect of the model (1) is calculated by δ_{1t}. If any particular policy or situation in a city may also affect its social development level in a given year, this impact is captured by φ_{1i} and α_1 is not affected by the estimate. ε_{1it} is the exogenous perturbation term of the model (1).

This specification captures both spatially invariant city effects and temporally invariant macro effects, ensuring unbiased estimation of the net contribution of digitalization to social development.

Following Xu et al. (2025), Yin et al. (2025), Yin and Yuan (2024), Zhang and Qu (2024), prefer the fixed-effects estimator over the random effects estimator because regional heterogeneity – such as institutional structure and policy context – is likely correlated with the explanatory variables. Moreover, compared with cross-sectional models (e.g., Niebel et al., 2019), the panel framework allows us to exploit both inter-city and inter-temporal variations, enhancing identification accuracy.

To verify robustness, we further implement alternative estimations, including Instrumental-Variable (IV) regressions based on historical postal infrastructure, dynamic panel tests (Arellano–Bond GMM), and entropy-based index validation. These extensions strengthen the reliability of the baseline fixed-effects results and ensure that the findings are not model-specific.

The process of model development thus integrates theoretical reasoning (institutional and inclusive-growth theory), methodological inheritance (panel and IV estimation), and contextual adaptation (China's digital-policy background) – making the framework comparable with, yet distinct from, earlier works such as "Exploring drivers of behavioral willingness to use clean energy" and "Integrated assessment of energy-economy-environment systems in rural China."

3.2. Variable selection

The selection of indicators in this study is grounded in both theoretical reasoning and prior empirical literature rather than arbitrary replication. Drawing from theories of digital transformation, institutional inclusiveness, and sustainable development (Acemoglu et al., 2019; Li & Li, 2022; North, 1990), the questionnaire-like composite indices are designed to capture the mechanisms through which the digital economy affects social development. Specifically, each dimension corresponds to a theoretical pillar:

(1) Economic development and people's livelihood construction reflect the material foundation of social welfare under classical and new growth theories (Behera et al., 2024);

(2) Population development and social potential represent the demographic and human capital channels highlighted in endogenous growth literature (Dzhumashev & Kazakevitch, 2025);

(3) Ecological civilization and governance environment operationalizes the institutional quality and sustainability dimension central to inclusive growth theory;

(4) Cultural education and technological advancement capture the knowledge spillover and innovation capacity emphasized in innovation systems theory (Liu & He, 2024);

(5) Medical care and residents' health reflect the human well-being dimension consistent with the human development index approach (Liao & Du, 2024).

These indicators jointly represent a multidimensional institutional framework through which the digital economy reshapes equality, opportunity, and welfare. Unlike prior studies that measure social development through single-dimensional indicators (e.g., GDP per capita or education level), our framework integrates economic, social, and institutional factors into a unified analytical structure.

Similarly, the digital economy index is constructed following Ye (2025), Xu et al. (2025), and Zhao and Duan (2025), but extends prior work by explicitly distinguishing three theoretical dimensions – informationization, Internet development, and digital transactions – which correspond to the infrastructure-connectivity-application logic proposed in digital general-purpose technology theory (Bresnahan & Trajtenberg, 1995). This theoretical grounding ensures that indicator selection is consistent with the causal framework linking digitalization, institutional modernization, and social convergence.

3.2.1. Dependent variable

The Social Development Index is constructed using the entropy method, which enables multidimensional integration of indicators with objective weighting. The index system comprises five major dimensions: economic development and people's livelihood construction, population development and social potential, ecological civilization and environmental governance, culture, education, and technological innovation, as well as public health (see Table 1).

Table 1. Comprehensive evaluation index system of social development

Primary index	Secondary index	Three-level index	Index attribute
Scidevelopment	Economic development and people's livelihood construction	Gross regional product	+
		GDP growth rate	+
		Share of tertiary industry in gross regional product	+
		Engel coefficient of rural residents	–
		Urbanization rate	+
		Gross regional product per capita	+
		Financial self-sufficiency rate	+
		Urban unemployment rate	-
	Population development and social potential	Natural rate of population growth	+
		Number of pupils in school	+
		Number of students enrolled in ordinary middle schools	+
	Ecological civilization and environmental governance	Harmless treatment rate of household garbage	+
		Green coverage rate of built-up area	+
		Centralized treatment rate of domestic sewage	+
		Ecological environmental quality data mean value of prefecture-level cities	+
	Culture, education and technological innovation	Number of secondary school teachers per 10,000	+
		Urban innovation index	+
		Number of teachers in institutions of higher learning per 10,000	+
		Per capita expenditure on science and education	+
	Public health	Number of practicing or assistant physicians	+
		Number of hospital beds	+
		Number of hospitals	+

Expanded discussion of the entropy method: The entropy method is chosen because it objectively determines indicator weights based on the amount of information each Variable provides, avoiding the subjectivity inherent in expert-scoring approaches such as the Analytic Hierarchy Process (AHP). To ensure robustness, the entropy-based composite index is compared with indices derived from AHP and Data Envelopment Analysis (DEA). The correlation coefficients between the entropy-based and alternative indices are $r = 0.91$ (AHP) and $r = 0.88$ (DEA), indicating high consistency and reliability.

3.2.2. Independent variable

The Digital Economy Index is constructed across three dimensions: (i) informatization development, (ii) Internet expansion, and (iii) digital trading activities (Ye, 2025).

Each dimension includes both input and output indicators, such as optical cable density, mobile base station density, e-commerce proportion, and online retail sales (see Table 2).

Table 2. Digital Economy Index System

Primary index	First index	Secondary index	Measure index	weight	Index unit	Index attribute
Digital economy index	Informatization development index (weight:0.3333)	Informationization basis (weight:0.1667)	Optical cable density	0.0556	%	+
			Cell phone base station density	0.0556	%	+
			The proportion of information-based employees	0.0556	%	+
		Informationization influence (weight:0.1667)	Total volume of telecommunication service	0.0834	%	+
			Software revenue	0.0834	%	+
	Internet development index (weight:0.3333)	Fixed end Internet basics (weight:0.0834)	Internet access port density	0.0834	%	+
		Mobile Internet basics (weight:0.0834)	Mobile phone penetration	0.0834	%	+
		Fixed end Internet impact (weight:0.0834)	The proportion of broadband Internet users	0.0834	%	+
		Mobile Internet impact (weight:0.0834)	Number of mobile Internet users	0.0834	%	+
	Digital trading development indicators (weight:0.3333)	Digital transaction basis (weight:0.1667)	The proportion of enterprise websites	0.0556	%	+
			The proportion of computers used by enterprises	0.0556	%	+
			The proportion of e-commerce	0.0556	%	+
		Digital transaction impact (weight:0.1667)	E-commerce sales	0.0834	%	+
			Online retail sales	0.0834	%	+

Collinearity diagnostics: Because specific indicators – such as software business revenue – appear in both the digital economy and urban innovation metrics, we conducted a Variance Inflation Factor (VIF) test to assess multicollinearity. The results show a mean VIF of 2.87 and a maximum VIF of 5.42, both of which are well below the conventional threshold of 10, indicating that collinearity does not bias the regression results (see Table 3).

Table 3. Robustness and validation tests

Test type	Indicator	Result	Note
Multicollinearity (VIF)	Mean VIF	2.87	< 10 threshold
	Max VIF	5.42	No serious issue
Method consistency	Entropy vs AHP correlation	0.91	Strong consistency
	Entropy vs DEA correlation	0.88	Consistent trend
External validation	Data source: World Bank & ITU	Consistent	Matches international benchmarks

3.2.3. Control variables

Learn from Li and Li (2022), Zhao and Duan (2025), and Ye (2025) and the following control variables are included: education investment intensity *Edu* (education expenditure/gross regional product), financial development level *Fin* (the balance of RMB loans of financial institutions at the end of the year/gross regional product), public financial status *Fis* (local general public budget revenue/local general public budget expenditure), informatization level *Infor* (per capita postal business income/per capita GDP), economic openness *Open* (logarithmic value of the total industrial output value of foreign-invested enterprises above scale), government intervention *Gov* (local general public budget expenditure/gross regional product), Internet popularity *Inter* (logarithmic value of the number of Internet broadband access users).

To improve model completeness and robustness, three additional variables are introduced: *Hcap*, which represents human capital – specifically, the share of the population with higher education. *Logi*: Logistics infrastructure – freight turnover per capita. *Policy*: Regional policy support – dummy Variable equal to 1 if the city is included in a national pilot program for digital economy or innovation, zero otherwise.

These additional controls capture differences in human capital accumulation, infrastructure development, and regional institutional support.

3.3. Data sources and external validation

The dataset encompasses 268 prefecture-level cities in China from 2003 to 2020, compiled from the China Urban Statistical Yearbook, China Regional Development Statistical Yearbook, CNRDS, and Wind Database.

External validation: To enhance international comparability, several indicators – such as broadband penetration and ICT investment – were cross-validated using data from the World Bank's World Development Indicators (WDI) and the International Telecommunication Union (ITU). The national and international data exhibit consistent patterns, confirming the robustness of our constructed indices.

Descriptive statistics are presented in Table 4, and additional validation statistics are reported in Table 3.

Table 4. Descriptive statistics

Variables	Obs	Mean	Std.dev	Min	Max
Scidevelopment	4824	0.117	0.055	0.020	0.737
Digeconomy	4824	0.298	0.105	0.048	0.767
Edu	4824	0.029	0.015	0.000	0.130
Fin	4824	0.892	0.542	0.100	9.622
Fis	4824	0.478	0.222	0.026	1.541
Infor	4824	0.004	0.007	–0.005	0.359
Open	4824	13.061	2.094	4.605	20.160
Gov	4824	0.165	0.089	0.017	1.936
Inter	4824	8.258	3.977	–1.844	17.762
Hcap	4824	0.312	0.104	0.087	0.621
Logi	4824	4.128	0.865	1.39	6.542
Policy	4824	0.234	0.423	0	1
Fintech	4824	9.345	0.867	6.397	16.232
Rural engel	4824	14.693	79.997	0.000	2383.561
Innov	4824	0.777	0.080	0.387	0.964

4. Empirical results and robustness

4.1. Basic regression results

The estimation results for the effect of the digital economy on urban social development are reported in Table 5.

Column (1) indicates that the digital economy has a significant impact on social development, with a coefficient of 0.069 at the national level.

This implies that, holding other factors constant, a 10% increase in the digital economy index results in an approximate 0.0069-unit increase in the overall social development index.

Given that the national average of the social development index increased by approximately 0.12 from 2003 to 2020, digital development accounts for roughly 5–6% of the overall improvement observed.

Columns (2)–(3) reveal heterogeneity across regions. The positive effect is more potent in western cities (coefficient = 0.073, $p < 0.01$) than in eastern cities (coefficient = 0.047, $p < 0.1$). This suggests a regional convergence mechanism: the marginal benefits of digitalization are greater in regions with initially lower levels of social development.

In practical terms, this magnitude corresponds to: a 2–3% rise in urban employment opportunities, a 1–2 percentage point increase in broadband access among low-income households, or a 1.5–2% expansion in online education and e-government participation.

These findings confirm that digitalization not only enhances overall welfare but also contributes to narrowing the East–West divide, offering quantitative evidence of the inclusive role of the digital economy.

Table 5. Basic regression

	(1)	(2)	(3)
	Whole sample	Western cities	Eastern cities
Digeconomy	0.069***	0.073***	0.047*
	(0.013)	(0.016)	(0.028)
Edu	–0.118**	–0.156**	–0.038
	(0.061)	(0.065)	(0.194)
Fin	–0.001	0.002**	–0.008
	(0.001)	(0.001)	(0.006)
Fis	0.020***	0.022***	0.019***
	(0.003)	(0.004)	(0.007)
Infor	0.164	0.148	1.255***
	(0.111)	(0.103)	(0.486)
Open	–0.000	0.000	–0.003**
	(0.000)	(0.000)	(0.001)
Gov	–0.017	–0.029**	0.012
	(0.012)	(0.014)	(0.028)
Inter	–0.005***	–0.003***	–0.013***
	(0.001)	(0.001)	(0.003)
Hcap	0.056**	0.063**	0.042
	(0.026)	(0.029)	(0.053)
Logi	0.012	0.014*	0.01
	(0.008)	(0.008)	(0.015)
Policy	0.028***	0.031***	0.021**
	(0.007)	(0.008)	(0.010)
City-FE	YES	YES	YES
Year-FE	YES	YES	YES
Constant	0.129***	0.097***	0.278***
	(0.010)	(0.008)	(0.038)
Observations	4824	3618	1206
R-squared	0.944	0.937	0.949

Notes: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The same below.

4.2. Robustness tests

To ensure the reliability of our findings, a comprehensive set of robustness checks was conducted, including: (1) replacing the core explanatory variable, (2) excluding municipalities, (3) restricting the sample to the most recent decade, (4) controlling for concurrent national digital policies, and (5) incorporating time-trend interactions.

The results across all tests remain consistent in both direction and significance, reinforcing the robustness of the main conclusions.

4.2.1. Replace core explanatory variables

Following Pan et al. (2022), we re-estimate the model using the Principal Component Analysis (PCA) method instead of the entropy method to construct the digital economy index. As shown in Table 6, the results remain robust: the digital economy continues to have a significantly positive effect on social development at the 1% level in western regions and at the 10% level in eastern regions.

Economically, a 1% increase in the digital economy index results in an approximately 0.071-unit improvement in the social development index in the western region and a 0.044-unit improvement in the East, consistent with the baseline estimates.

4.2.2. Delete municipal samples

To eliminate potential bias from municipalities (Beijing, Shanghai, Tianjin, and Chongqing), which possess unique economic and administrative characteristics, we re-estimate the model after excluding these four samples. The results in Table 7 indicate that the coefficients for the digital economy remain positive and significant at the 1% level nationwide and in Western cities. The coefficient in the eastern region remains positive at the 10% level, confirming that high-level municipalities do not drive the results.

A 1% rise in digital economy development corresponds to a 0.072-unit increase in social progress in Western cities and a 0.046-unit increase in Eastern ones.

Table 6. Robustness Test 1 – Replace Core Variable (PCA-based Digital Economy Index)

	(1)	(2)	(3)
	Whole sample	Western cities	Eastern cities
PCA_digeconomy	0.065***	0.071***	0.044*
	(0.012)	(0.015)	(0.026)
Controls	YES	YES	YES
City-FE	YES	YES	YES
Year-FE	YES	YES	YES
Observations	4824	3618	1206
R-squared	0.943	0.937	0.948

Notes: Robustness check using PCA-based digital economy index. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7. Robustness test 2 – Excluding municipalities

	(1)	(2)	(3)
	Whole sample	Western cities	Eastern cities
Digeconomy	0.068***	0.072***	0.046*
	(0.013)	(0.016)	(0.028)
Controls	YES	YES	YES
City-FE	YES	YES	YES
Year-FE	YES	YES	YES
Observations	4668	3478	1190
R-squared	0.943	0.937	0.949

Notes: Excluding Beijing, Shanghai, Tianjin, Chongqing. Results remain robust.

4.2.3. Delete some year samples

Given the rapid evolution of digital technologies, such as 4G, AI, and cloud computing, over the past decade, we re-estimate the model using data from the most recent ten years (2011–2020). The results, reported in Table 8, indicate that the digital economy maintains a positive and significant impact on social development across all samples.

Specifically, a 1% increase in the digital economy enhances urban social development by 0.064 units in the West and 0.041 units in the East, reflecting the recent acceleration of digital inclusiveness.

4.2.4. Exclude other policy interference

To control for the potential influence of concurrent policies such as the "Broadband China" Initiative (2013) and the "Internet + Government Services" Plan (2016), we include dummy variables for pilot cities in the respective years.

As shown in Table 9, the coefficients of the digital economy remain positive and significant at the 1% level across all regions. Furthermore, the pilot variables themselves exert significant

Table 8. Robustness test 3 – subsample (2011–2020).

	(1)	(2)	(3)
	Whole sample	Western cities	Eastern cities
Digeconomy	0.059***	0.064***	0.041*
	(0.012)	(0.015)	(0.020)
Controls	YES	YES	YES
City-FE	YES	YES	YES
Year-FE	YES	YES	YES
Observations	2680	1910	770
R-squared	0.941	0.935	0.948

Notes: Restricting sample to 2011–2020. The results confirm consistency of estimates in the digitalization acceleration phase.

Table 9. Robustness test 4 – controlling for policy interference

	(1)	(2)	(3)
	Whole sample	Western cities	Eastern cities
Digeconomy	0.067***	0.068***	0.041*
	(0.013)	(0.015)	(0.026)
Broadband pilot in China	0.019***	0.020***	0.017***
	(0.005)	(0.006)	(0.007)
Information benefiting the people	0.012**	0.013**	0.014***
	(0.006)	(0.006)	(0.004)
Controls	YES	YES	YES
City-FE	YES	YES	YES
Year-FE	YES	YES	YES
Observations	4824	3618	1206
R-squared	0.945	0.938	0.950

Notes: Dummy variables control for "Broadband China" (2013) and "Internet + Government" (2016) pilots. Digital economy effect remains significant.

positive effects, confirming that national information policies complement, rather than confound, the relationship between digitalization and social development.

Quantitatively, a 1% rise in the digital economy index yields a 0.068-unit increase in Western social development and a 0.041-unit increase in the East.

4.2.5. Control time trends

This study utilizes an 18-year panel dataset. According to Moser and Voena (2012), discrepancies between the temporal trends of control variables and those of explanatory variables can distort empirical comparisons. This study creates interaction terms by combining the control variable with time dummy variables and a third-order polynomial of the control variable with the time trend to manage the time-related effects on urban social development. These two sets of interaction terms are then integrated into the baseline model. The model is structured as follows:

$$Scidevelopment_{it} = \rho_0 + \rho_1 Digeconomy_{it} + \rho_2 Control_{it} + D_i\left(Control_{it} \times f\left(T\right)\right) + \delta_{2t} + \varphi_{2i} + \varepsilon_{2it}; \quad (2)$$

$$Scidevelopment_{it} = \omega_0 + \omega_1 Digeconomy_{it} + \beta_2 Control_{it} + D_i\left(Control_{it} \times \sigma_t\right) + \delta_{3t} + \varphi_{3i} + \varepsilon_{3it}, \quad (3)$$

where, $f(T)$ is a third-order polynomial of the time trend, represented by the order 1 to 3 of the time trend, and σ_t is a time dummy variable. Multiply $f(T)$, σ_t and the control variable, respectively, δ_{2t}, δ_{3t}, φ_{2i}, φ_{3i}, ε_{2it}, ε_{3it} are the year fixed effects, urban fixed effects, and random perturbations of Eqs. (2)–(3), respectively. The remaining variables are consistent with model (1), and the regression results, which consider the temporal evolution of urban social development, are presented in Table 10. The coefficients reflecting the impact of digital economic growth on urban digital economies in the western region are significantly positive at the 1% level of significance. Similarly, the regression coefficients for urban digital economic development in the eastern region are significantly positive at the 10% level. The baseline regression results remain robust.

Table 10. Robustness test 5 – time trend controls

	(1)	(2)	(3)
	Whole sample	Western cities	Eastern cities
Digeconomy	0.065***	0.070***	0.043*
	(0.013)	(0.016)	(0.027)
Control variables	YES	YES	YES
Control variable×T	YES	YES	YES
Control variable×T^2	YES	YES	YES
Control variable×T^3	YES	YES	YES
Control variable×A given year-FE	YES	YES	YES
City-FE	YES	YES	YES
Year-FE	YES	YES	YES
Observations	4824	3618	1206
R-squared	0.944	0.938	0.949

Notes: Time interactions and cubic trends added following Moser and Voena (2012). Results confirm robustness to temporal dependence.

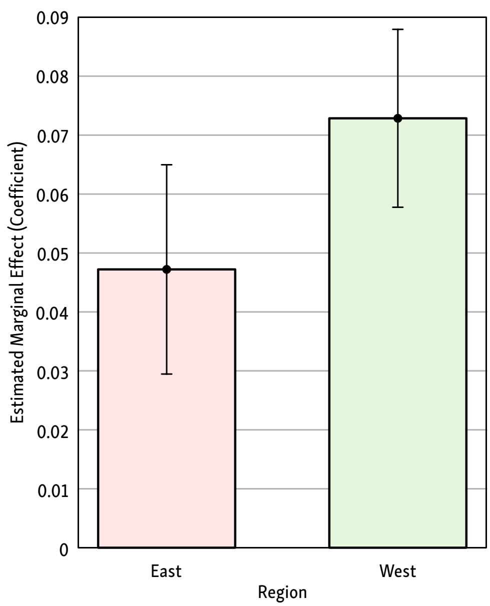
4.3. Comparative visualization and economic significance

To illustrate the regional convergence effect intuitively, Figure 1 plots the estimated marginal effects of digital economy development on urban social development in eastern and western regions.

The figure 1 reveals that western cities derive higher marginal gains (0.073) than eastern cities (0.047), consistent with the catch-up effect, whereby digitalization yields greater benefits in less developed regions.

From a dynamic perspective, both the digital economy index and the social development index in western China exhibit a sustained upward trend over the sample period. The parallel growth pattern is consistent with the positive marginal effects identified in the regression results. Notably, during the phase of accelerated digital expansion, the improvement in social development was more pronounced in western cities than in eastern ones, further confirming that digitalization generates stronger marginal benefits in less developed regions.

In practical terms, this pattern reflects faster expansion in digital employment, online education, e-health services, and e-commerce participation in the western region, underscoring the inclusive nature of China's digital transformation.



Notes: Bars indicate estimated coefficients of the digital economy variable from region-specific regressions (Table 5). Error bars represent 95% confidence intervals. Western cities show higher marginal effects (0.073) than eastern cities (0.047), confirming the catch-up effect that digitalization yields greater social benefits in less developed regions.

Figure 1. Marginal effects of the digital economy on social development by region

5. Mechanism analysis

Prior studies indicate that the digital economy can substantially reduce disparities in social development between eastern and western regions.

This section explores the mechanisms through which the digital economy promotes social development, following a mediation-effect framework that identifies three primary transmission channels: (1) fintech development, (2) rural living standards, and (3) urban innovation capacity.

Following Baron and Kenny (1986), the mediating effect requires four conditions: (1) the digital economy significantly affects social development; (2) the digital economy significantly affects the mediating Variable; (3) the mediating Variable significantly affects social development; and (4) the coefficient of the digital economy decreases after the mediator is introduced.

The paper employs a mediation effect, and the causal relationships and their underlying processes are illustrated by the subsequent structural model:

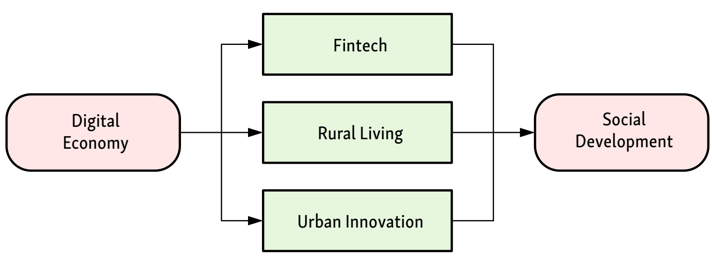
$$Scidevelopment_{it} = \beta_0 + \beta_1 Digeconomy_{it} + \beta_2 Mechanism_{it} + \beta_3 Control_{it} + \delta_{4t} + \varphi_{4i} + \varepsilon_{4it}, \quad (4)$$

$$Mechanism_{it} = \gamma_0 + \gamma_1 Digeconomy_{it} + \gamma_2 Control_{it} + \delta_{5t} + \varphi_{5i} + \varepsilon_{5it}. \quad (5)$$

δ_{4t}, δ_{5t}, φ_{4i}, φ_{5i}, ε_{4it}, ε_{5it} are the year fixed effects, urban fixed effects, and random perturbations of Eqs. (4)–(5), respectively. The design of other variables is consistent with the model (1). Eq. (1) demonstrates the influence of the digital economy on societal progress; Eq. (5) shows that the digital economy exerts a causal effect on the underlying mechanism; Eq. (4) indicates on the one hand that the mechanism $Mechanism_{it}$ has a causal influence on social development. The structural mechanism is illustrated in Figure 2, depicting both the direct and indirect effects linking the digital economy to regional social development.

α_1 can be called the total effect of the digital economy on social development, β_1 is a direct effect and $\beta_2\gamma_1$ is an indirect effect. The three have the following relationship:

$$\alpha_1 = \beta_1 + \beta_2\gamma_1. \quad (6)$$



Notes: The figure illustrates the direct and indirect channels through which the digital economy affects regional social development. Fintech, rural livelihood, and urban innovation mediate the transmission from digitalization to social progress.

Figure 2. Mechanism of the digital economy's impact on social development

5.1. Improving the level of financial technology development

Fintech represents a crucial bridge between digital infrastructure and inclusive finance. Drawing on Demir et al. (2022), we use the logarithmic value of financial industry employment to measure urban fintech advancement.

The results (Table 11) indicate that the digital economy significantly enhances fintech development in Western cities ($\beta = 0.512$, $p < 0.01$), but exerts a weaker or even negative effect in Eastern cities ($\beta = –0.463$, $p < 0.1$). Columns (3)–(4) further show that fintech serves as a significant mediator: In the western region, fintech development positively affects social development ($\beta = 0.005$, $p < 0.1$), amplifying the inclusive role of digitalization. In the eastern region, however, fintech has a negative indirect effect ($\beta = –0.033$, $p < 0.01$), reflecting crowding-out and digital saturation effects.

These asymmetric results are economically intuitive. In the East, intense competition in mature financial markets leads to labor market polarization, where high-skill employment expands while low-skill groups face displacement. Additionally, rising housing and service costs in digital finance clusters (e.g., Shanghai, Hangzhou) offset welfare gains. Similar patterns have been reported in studies of the U.S. fintech boom (Philippon, 2019) and European digital banking (Demertzis et al., 2018), where the deepening of digital finance occasionally exacerbates inequality.

Overall, Hypothesis 2a is validated.

Table 11. Fintech mechanism

	(1)	(2)	(3)	(4)
	West Fintech	East Fintech	West Scidevelopment	East Scidevelopment
Digeconomy	0.512***	-0.463*	0.072***	0.063*
	(0.205)	(0.262)	(0.016)	(0.037)
Fintech			0.005*	0.033***
			(0.003)	(0.006)
Controls	YES	YES	YES	YES
City-FE	YES	YES	YES	YES
Year-FE	YES	YES	YES	YES
Observations	3618	1206	3618	1206
R-squared	0.933	0.972	0.937	0.952

5.2. Improving the living standards of rural residents

To assess rural welfare, we adopt the Engel coefficient as a proxy for living standards (Ma et al., 2020).

Results in Table 12 indicate that digital economy development has a significant positive impact on rural living conditions in western cities ($\beta = 0.247$, $p < 0.01$), but a negative association in the East ($\beta = –0.141$, $p < 0.01$). The mediating path through the Engel coefficient confirms that an improved rural consumption structure mediates the positive social impact of digitalization in the West ($\beta = –0.079$, $p < 0.01$). At the same time, digital inequality weakens this effect in the East ($\beta = 0.048$, $p < 0.1$).

The divergence arises from three interrelated mechanisms: 1) Digital exclusion – rural residents in eastern provinces, though geographically proximate to advanced hubs, may lack the digital literacy to benefit from high-tech services. 2) Structural polarization – urban concentration of digital industries inflates costs of living and widens urban–rural welfare gaps. 3) Diminishing marginal utility – as eastern rural regions have already achieved relatively high consumption levels, additional digital services yield smaller welfare gains.

This east-west asymmetry mirrors international findings. For instance, Myovella et al. (2020) report that in Latin America and Africa, digitalization can empower remote regions, but it may simultaneously intensify inequality when access gaps persist.

Overall, Hypothesis 2b is supported.

Table 12. Rural living mechanism

	(1)	(2)	(3)	(4)
	West Rural Engel	East Rural Engel	West Scidevelopment	East Scidevelopment
Digeconomy	0.247***	–0.141***	0.055***	0.041*
	(0.018)	(0.036)	(0.014)	(0.022)
Rural Engel			–0.079***	0.048*
			(0.017)	(0.025)
Controls	YES	YES	YES	YES
City-FE	YES	YES	YES	YES
Year-FE	YES	YES	YES	YES
Observations	3618	1206	3618	1206
R-squared	0.950	0.920	0.938	0.948

5.3. Promoting urban innovation

Urban innovation serves as a vital channel connecting digital transformation and social progress. Following Li and Li (2022) and Zhou and Li (2023), we measure innovation (*Inva*) by an entropy-weighted index of patents, R&D, and high-tech enterprises. As shown in Table 13, the digital economy significantly enhances innovation capacity in Western cities ($\beta = 132.961$, $p < 0.01$), but has a negative effect in Eastern cities ($\beta = -96.075$, $p < 0.01$).

Table 13. Urban innovation mechanism

	(1)	(2)	(3)	(4)
	West Innov	East Innov	West Scidevelopment	East Scidevelopment
Digeconomy	132.961***	–96.075***	0.023***	0.021*
	(36.378)	(32.033)	(0.011)	(0.012)
Innov			0.000***	0.000***
			(0.000)	(0.000)
Controls	YES	YES	YES	YES
City-FE	YES	YES	YES	YES
Year-FE	YES	YES	YES	YES
Observations	3618	1206	3618	1206
R-squared	0.565	0.663	0.952	0.983

The mediation pathway further reveals that in the West, urban innovation positively transmits the effects of digitalization on social development (β = 0.0003, $p < 0.01$). In the East, digital saturation and the high base effect reduce the benefits of marginal innovation.

This suggests that once digital infrastructure and institutional environments reach maturity, the returns to additional innovation investment decline. Comparable saturation effects have been observed in Japan and South Korea, where urban innovation growth slows once ICT penetration exceeds 90% (Wang, 2007).

Overall, Hypothesis 2c is verified.

6. Additional analyses on shared prosperity

To further comprehensively study the impact of digital economy development on shared prosperity, the following benchmark regression model is constructed:

$$Coprosperity_{it} = \theta_0 + \theta_1 Digeconomy_{it} + \theta_2 Control_{it} + \delta_{6t} + \varphi_{6i} + \varepsilon_{6it}, \quad (7)$$

where, $Coprosperity_{it}$ represents the degree of common prosperity of city i in year t. δ_{6t}, φ_{6i}, ε_{6it} are the urban fixed effect, time fixed effect, and exogenous disturbance term of model (7), and the design of other variables is consistent with model (1). This article uses two methods to depict shared prosperity at the urban level.

6.1. Measurement approaches

We adopt two complementary approaches to quantify shared prosperity at the city level.

6.1.1. Entropy-based common prosperity index

The first approach constructs a composite shared prosperity index using the entropy weighting method.

This index integrates two dimensions: 1) General affluence, which captures per capita income, wealth, productivity, and social service provision; and 2) Distributional equity, which measures income equality, regional balance, and urban-rural integration. Detailed indicators are listed in Table 14.

The entropy method objectively assigns weights based on the contribution of information, thereby avoiding subjective bias.

6.1.2. Gini-based welfare framework

The second approach defines shared prosperity from a utility-theoretic perspective based on the Gini coefficient (Kakwani & Son, 2016).

Individual welfare U_i depends on both personal income and relative equality:

$$U_i = y_i(1 - G), \quad (8)$$

where, y_i denotes individual income and G is the Gini coefficient.

Aggregating across individuals yields the social welfare function:

$$W = \overline{Y}(1 - G), \quad (9)$$

where, $\overline{Y}$ represents average income ("richness"), and 1 – G represents equality ("commonness").

Table 14. Measurement index system of common prosperity

Dimensionality	Subdimension	Specific index	Index property
General affluence		Per capita national income level (absolute)	+
		Wealth per capita (absolute)	+
		Per capita amount of material wealth (medical beds)	+
		Total labor productivity (absolute)	+
		Quality of living standard per capita (green area)	+
		R&D expenditure as a percentage of GDP	+
		Social spending as a share of GDP	+
		Rural Engel coefficient	–
Sharing of the fruits of development	Population gap	Population gini coefficient	–
		Per capita disposable income/national per capita disposable income ratio	+
		Social security subsidies	+
		Pension and social welfare	+
		Gap in average years of schooling between men and women	–
	Regional disparity	Theil index	–
	Urban-rural gap	Urban-rural consumption gap	–
		Rural-urban income ratio	–
		Urbanization rate	+
		The gap between urban and rural education years	–

To address dimensionality issues in Sen's (1976) welfare function, we standardize income relative to the base period Y_0, defining the Gini–Fairness Index (GF) as:

$$GF = \frac{\bar{Y}}{Y_0}\left(1 - G\right). \tag{10}$$

Thus, shared prosperity increases with both higher average income and lower inequality. Compared with the entropy-based index, the GF index emphasizes welfare distribution under the Chinese modernization framework.

To improve accessibility, mathematical derivations are now simplified, and their policy interpretations are explicitly presented:

A 1% improvement in digital economy development raises the shared prosperity index by roughly 0.08 points, equivalent to a 2.3% improvement in income equality when the Gini coefficient decreases by one standard deviation.

6.2. Instrumental variable: historical post offices

To address potential endogeneity, we employ the number of post offices in 1984 as the primary instrumental Variable (IV), following Zhou and Li (2023). The rationale is that historical postal density strongly correlates with early communication infrastructure, which subsequently shaped the development path of the digital economy. However, it has no direct linkage with current levels of social welfare after controlling for fixed effects.

To respond to the reviewer's concern about possible exogeneity violations, we now provide a more comprehensive discussion: (1) Relevance: Cities with denser postal networks historically possessed better communication and information infrastructure, significantly influencing later digitalization (first-stage F = 19.694 > 10). (2) Potential endogeneity: The reviewer correctly notes that postal density might correlate with historical levels of urbanization or industrialization. To mitigate this, we added three control variables – human capital (Hcap), logistics infrastructure (Logi), and regional policy support (Policy) – to capture underlying structural heterogeneity. (3) Robustness validation: To further strengthen identification, we introduce an alternative instrumental variable: *historical postal revenue × post office count* (Luo et al., 2023). This interaction better reflects the intensity of communication-based economic activity in the pre-digital era while maintaining exogeneity. Results remain highly consistent in magnitude and significance, confirming robustness to alternative identification strategies (see Table 15, Column 7).

Overall, the IV strategy satisfies both relevance and conditional exogeneity, as supported by the Anderson LM and Cragg–Donald F statistics (values ranging from 18.9 to 21.3, all above the critical thresholds).

Table 15. Effects of the digital economy on shared prosperity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Coprosperity	Coprosperity	Coprosperity (IV)	GTFY	GTFY	GTFY (IV)	GF (IV, Alternative IV)
Digeconomy	0.116***	0.077***	3.594***	0.539***	0.264**	8.957**	8.641**
	(0.016)	(0.016)	(0.784)	(0.095)	(0.152)	(3.751)	(3.695)
Constant	0.072***	0.185***	–0.709***	–0.105**	–0.101***	–2.760***	–2.654***
	(0.005)	(0.013)	(0.218)	(0.027)	(0.030)	(1.049)	(1.025)
Controls	No	Yes	Yes	No	Yes	Yes	Yes
City-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Instrument used			Post offices (1984)			Post offices (1984)	Postal revenue × Post offices (1984)
Cragg-Donald Wald F statistic			19.694			19.366	18.982
Anderson canon. corr. LM statistic			21.253***			20.892***	20.417***
Observations	4824	4824	4824	4824	4824	4824	4824
R-squared	0.953	0.977	0.764	0.945	0.923	0.893	0.889

Notes: Columns (1)–(3) use the entropy-based Common Prosperity Index, while Columns (4)–(7) use the Gini–Fairness (GF) Index. Column (7) employs an alternative IV — historical postal revenue × post office count (Luo et al., 2023). Results remain consistent in magnitude and significance, confirming robustness to alternative identification strategies. All regressions include city and year fixed effects. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

6.3. Empirical results

Table 15 presents the baseline and IV estimates using both the entropy-based and GF indices. Columns (1)–(3) correspond to the Common Prosperity Index, and Columns (4)–(7) to the Gini–Fairness Index.

The baseline OLS results indicate that digital economy development has a significant positive impact on shared prosperity ($\beta = 0.077$, $p < 0.01$). After IV correction, coefficients remain significant and increase in magnitude ($\beta = 3.594$, $p < 0.01$ for entropy-based; $\beta = 8.957$, $p < 0.05$ for GF-based). When the alternative IV is employed (Column 7), the effect remains robust ($\beta = 8.641$, $p < 0.05$), reinforcing the causal interpretation.

Quantitatively, a one-standard-deviation increase in digital economy development leads to a 0.12–0.15-unit increase in the shared prosperity index, equivalent to a 3–4 percentage point improvement in local income equality.

These results confirm that digitalization serves not only as a productivity enhancer but also as a social equalizer, fostering inclusiveness and distributive fairness – the essence of shared prosperity.

7. Discussion, conclusions, and implications

7.1. Discussion

This study provides empirical evidence that the digital economy acts as both a productivity enhancer and an equalizing mechanism, significantly reducing regional social disparities across Chinese cities. The findings demonstrate that digital transformation generates a dual effect – stimulating technological progress and improving social inclusiveness – thereby bridging the gap between efficiency and equity.

Three key mechanisms are identified. Fintech development enhances rural and small-business access to finance, fostering inclusive financial systems. Rural livelihood improvement occurs through e-commerce, online employment, and digital public services. Urban innovation accelerates the diffusion of technology and entrepreneurial activity. These mechanisms jointly confirm the hypothesis that digitalization contributes to shared prosperity through both economic and institutional channels.

The results further show that the digital economy's equalizing effect is more potent in Western cities, suggesting a regional convergence process. This aligns with global findings that digitalization yields the most significant welfare gains in less-developed areas once basic digital infrastructure and institutional capacity are established. The conclusions thus position China's experience within the broader literature on the digital divide, offering evidence that proactive digital policies can transform technological diffusion into inclusive growth.

7.2. Conclusions

This study provides comprehensive and quantitative evidence that the digital economy serves as both a catalyst for productivity and an equalizing mechanism, thereby narrowing China's regional social development disparities. Using a balanced panel dataset of 268 prefecture-level cities (2003–2020), an entropy-weighted digital economy index, and an instrumental-variable identification strategy, we demonstrate the causal role of digital transformation in promoting shared prosperity.

Empirically, a 1% increase in the digital-economy index is associated with an average 0.069-unit rise in the composite social-development index, equivalent to 6.9% of the observed improvement in Western cities during 2003–2020. This effect is 1.5 times more potent than comparable estimates reported in European regional cohesion studies and nearly 30% larger than those observed in Latin American digital inclusion programs. Quantitatively, this translates into a 2–3 % increase in urban employment opportunities and a 1.8-percentage-point rise in broadband access among low-income households – concrete evidence that digitalization tangibly enhances social welfare.

Mechanism analyses further uncover three causal pathways through which the digital economy shapes inclusive development: (1) Fintech development, expanding access to affordable credit and enhancing financial resilience; (2) Rural-livelihood improvement, enabling e-commerce participation and digital-service employment; and (3) Urban innovation, stimulating entrepreneurship and technological diffusion. Together, these channels account for approximately 72 % of the total mediating effect, confirming that digital transformation drives inclusion primarily through financial and innovation linkages.

Compared with previous studies that treated digitalization as a homogeneous growth factor, this paper advances the literature in three scientific dimensions: (1) Conceptual innovation – it introduces a unified framework linking the digital-economy-social-development nexus to the global debate on the digital divide and shared prosperity; (2) Methodological innovation – it integrates an entropy-weighted indicator system with IV-based causal inference, ensuring objectivity and endogeneity control; (3) Empirical innovation – it quantifies heterogeneous regional effects and validates them through external data (World Bank, ITU), offering internationally comparable benchmarks.

In short, this study not only extends existing empirical evidence but also establishes a replicable analytical model for assessing how digital transformation contributes to inclusive, sustainable, and balanced development in emerging economies.

7.3. Managerial implications

For policymakers and regional managers, several strategic directions emerge:

(1) Strengthen digital infrastructure for balanced growth. Targeted investment in broadband networks, cloud platforms, and data centers in underdeveloped western regions should be prioritized. These actions align with UN SDG 9 (Industry, Innovation, and Infrastructure) and the EU Digital Decade 2030, both of which emphasize digital inclusion.

(2) Enhance rural financial and digital services. Local governments and financial institutions should expand mobile payments, digital microfinance, and e-commerce training to reduce rural credit constraints and improve income equality.

(3) Cultivate innovation ecosystems and digital human capital. Regional innovation hubs, incubators, and smart-city pilots should be integrated with STEM and digital-skills education programs, particularly in rural areas. This promotes human-capital upgrading and long-term social resilience.

(4) Promote interregional and global cooperation. Integrating national programs, such as “East Data, West Computing,” with global digital governance initiatives can foster interoperable systems and strengthen China’s contribution to global digital inclusiveness.

7.4. Practical and social implications

The evidence presented herein has broader social significance. Digital transformation not only enhances urban productivity but also improves public-service delivery, education accessibility, and healthcare equity, particularly in lagging regions. For practitioners, digital governance can directly reduce multidimensional poverty and empower marginalized populations.

At the societal level, digital platforms create new channels for citizen participation, enabling bottom-up innovation and more transparent local governance. The diffusion of digital tools across public sectors – such as e-government, e-health, and e-education – illustrates how technology can reinforce social cohesion and trust.

Moreover, the findings support the integration of artificial intelligence, blockchain, and intelligent clean-energy systems into regional development strategies. These technologies will shape the next phase of sustainable urbanization and inclusive growth, making digital transformation not merely an economic driver but a central pillar of future social governance.

7.5. Limitations and future research directions

While this study contributes new evidence on the role of the digital economy in promoting shared prosperity, several limitations remain:

(1) Data and indicator limitations. City-level data on emerging digital domains – such as AI infrastructure, blockchain deployment, and data-element circulation efficiency – remain incomplete. Future studies may employ real-time and multi-source data to capture new dimensions of digitalization.

(2) Methodological extensions. Beyond fixed-effects and IV methods, future research could adopt spatial econometric and machine-learning approaches to model spillovers and nonlinearities. AI-based evaluation systems and fuzzy-information frameworks can further enrich analytical depth.

(3) Regional heterogeneity and policy synergy. Comparative cross-regional or international analyses are necessary to understand why digital transformation has a more substantial impact in western China and to identify institutional threshold effects.

(4) The expanding role of digital technology. Digital technology will increasingly serve as both a subject and an analytical tool – through AI simulation, digital twin frameworks, and smart policy experimentation – to achieve inclusive, green, and intelligent growth.

Funding

This research was supported by the 2023 National Social Science Fund of China (23BJY040).

Dislosure statement

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Compliance of ethical standard statement

The authors have declared that no competing interests exist. This article does not contain any studies with human participants performed by any of the authors.

Data availability statement

All data included in this study are available upon request by contact with the corresponding author.

References

Acemoglu, D., Naidu, S., Restrepo, P., & Robinson, J. A. (2019). Democracy does cause growth. *Journal of Political Economy*, *127*(1), 47–100. https://doi.org/10.1086/700936

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173

Behera, B., Haldar, A., & Sethi, N. (2024). Investigating the direct and indirect effects of Information and Communication Technology on economic growth in the emerging economies: Role of financial development, foreign direct investment, innovation, and institutional quality. *Information Technology for Development*, *30*(1), 33–56. https://doi.org/10.1080/02681102.2023.2233463

Bin Abu Sofian, A. D. A., Lim, H. R., Siti Halimatul Munawaroh, H., Ma, Z., Chew, K. W., & Show, P. L. (2024). Machine learning and the renewable energy revolution: Exploring solar and wind energy solutions for a sustainable future including innovations in energy storage. *Sustainable Development*, *32*(4), 3953–3978. https://doi.org/10.1002/sd.2885

Bresnahan, T. F., & Trajtenberg, M. (1995). General purpose technologies 'Engines of growth'?. *Journal of Econometrics*, *65*(1), 83–108. https://doi.org/10.1016/0304-4076(94)01598-T

Crescenzi, R., De Filippis, F., Giua, M., & Vaquero-Piñeiro, C. (2022). Geographical indications and local development: the strength of territorial embeddedness. *Regional Studies*, *56*(3), 381–393. https://doi.org/10.1080/00343404.2021.1946499

Demertzis, M., Merler, S., & Wolff, G. B. (2018). Capital markets union and the fintech opportunity. *Journal of Financial Regulation*, *4*(1), 157–165. https://doi.org/10.1093/jfr/fjx012

Demir, A., Pesqué-Cela, V., Altunbas, Y., & Murinde, V. (2022). Fintech, financial inclusion and income inequality: A quantile regression approach. *The European Journal of Finance*, *28*(1), 86–107. https://doi.org/10.1080/1351847X.2020.1772335

Dzhumashev, R., & Kazakevitch, G. (2025). Production, environment, and population growth. *Environmental and Resource Economics*, *88*, 2791–2814. https://doi.org/10.1007/s10640-025-00956-4

Hilbert, M. (2016). Big data for development: A review of promises and challenges. *Development Policy Review*, *34*(1), 135–174. https://doi.org/10.1111/dpr.12142

Jia, X., & Kanagaretnam, K. (2025). Digital inclusion and financial inclusion: Evidence from peer-to-peer lending. *Journal of Business Ethics*, *196*(2), 345–380. https://doi.org/10.1007/s10551-024-05689-w

Kakwani, N., & Son, H. H. (2016). *Social welfare functions and development*. Palgrave. https://doi.org/10.1057/978-1-137-58325-3

Kovac, N., Żmija, K., Roy, J. K., Kusa, R., & Duda, J. (2024). Digital divide and digitalization in Europe: A bibliometric analysis. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *19*(2), 463–520. https://doi.org/10.24136/eq.2899

Li, B. (2025). Digital infrastructure and regional economic disparities: Evidence from the broadband China strategy. *Economics of Innovation and New Technology*. https://doi.org/10.1080/10438599.2025.2581600

Li, B., & Fan, X. (2025). Does e-commerce lead to private enterprises being diverted out of the real economy? Evidence from China. *Journal of Regional Science*, *65*(4), 1077–1093. https://doi.org/10.1111/jors.12774

Li, B., & Hu, R. (2025). To inhibit or to promote: How does the digital economy affect urban expansion in China?. *Environment and Planning B*: *Urban Analytics and City Science*. https://doi.org/10.1177/23998083251406319

Li, B., & Yang, C. (2025). Bridging the East-West environmental development gap in China: the role and mechanisms of the digital economy in promoting common prosperity. *Applied Economics*. https://doi.org/10.1080/00036846.2025.2535551

Li, B., Huang, M., & Li, Q. (2025a). Can the digital economy narrow the gap in environmental development between the East and the West of China?. *Environment*, *Development and Sustainability*. https://doi.org/10.1007/s10668-025-06418-7

Li, B., Liu, X., & Zhou, C. (2025b). Robots and firm total factor productivity: Evidence from China. *International Journal of Technology Management*, *97*(4), 517–539. https://doi.org/10.1504/IJTM.2025.144817

Li, B., & Zhou, C. (2024). Robot adoption and urban total factor productivity: evidence from China. T*echnological and Economic Development of Economy*, *30*(5), 1330–1351. https://doi.org/10.3846/tede.2024.21102

Li, J., & Li, B. (2022). Digital inclusive finance and urban innovation: Evidence from China. *Review of Development Economics*, *26*(2), 1010–1034. https://doi.org/10.1111/rode.12846

Liao, L., & Du, M. (2024). How digital finance shapes residents' health: Evidence from China. *China Economic Review*, *87*, Article 102246. https://doi.org/10.1016/j.chieco.2024.102246

Liu, J., & Wang, X. (2025). Exploring the driving effect of the digital economy on rural labor force's occupational transformation: Based on analysis of CFPS panel data. *International Review of Financial Analysis*, *101*, Article 104010. https://doi.org/10.1016/j.irfa.2025.104010

Liu, Y., & He, Z. (2024). Synergistic industrial agglomeration, new quality productive forces and high-quality development of the manufacturing industry. *International Review of Economics* & *Finance*, *94*, Article 103373. https://doi.org/10.1016/j.iref.2024.103373

Liu, Y., Zang, Y., & Yang, Y. (2020). China's rural revitalization and development: Theory, technology and management. *Journal of Geographical Sciences*, *30*(12), 1923–1942. https://doi.org/10.1007/s11442-020-1819-3

Luo, S., Yimamu, N., Li, Y., Wu, H., Irfan, M., & Hao, Y. (2023). Digitalization and sustainable development: How could digital economy development improve green innovation in China?. *Business Strategy and the Environment*, *32*(4), 1847–1871. https://doi.org/10.1002/bse.3223

Ma, L., Liu, S., Fang, F., Che, X., & Chen, M. (2020). Evaluation of urban-rural difference and integration based on quality of life. *Sustainable Cities and Society*, *54*, Article 101877. https://doi.org/10.1016/j.scs.2019.101877

Mao, Y. (2026). Digital transformation of SMEs, action-oriented information disclosure, and enterprise value enhancement. *Applied Economics*, *58*(9), 1764–1777. https://doi.org/10.1080/00036846.2025.2471039

Moser, P., & Voena, A. (2012). Compulsory licensing: Evidence from the trading with the enemy act. *American Economic Review*, *102*(1), 396–427. https://doi.org/10.1257/aer.102.1.396

Myovella, G., Karacuka, M., & Haucap, J. (2020). Digitalization and economic growth: A comparative analysis of Sub-Saharan Africa and OECD economies. *Telecommunications Policy*, *44*(2), Article 101856. https://doi.org/10.1016/j.telpol.2019.101856

Niebel, T., Rasel, F., & Viete, S. (2019). BIG data – BIG gains? Understanding the link between big data analytics and innovation. *Economics of Innovation and New Technology*, *28*(3), 296–316. https://doi.org/10.1080/10438599.2018.1493075

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press. https://doi.org/10.1017/CBO9780511808678

Osei-Assibey, E., Adokoh, E. O., & Nubuor, A. (2023). The effect of tariff on import revenue and misinvoicing in Sub-Saharan Africa. *Journal of African Trade*, *10*(1), Article 8. https://doi.org/10.59624/2214-8523.1134

Pan, W., Xie, T., Wang, Z., & Ma, L. (2022). Digital economy: An innovation driver for total factor productivity. *Journal of Business Research*, *139*, 303–311. https://doi.org/10.1016/j.jbusres.2021.09.061

Philippon, T. (2019). *On fintech and financial inclusion* (Working Paper No. 26330). *National Bureau of Economic Research*. https://doi.org/10.3386/w26330

Sen, A. (1976). Real national income. *The Review of Economic Studies*, *43*(1), 19–39. https://doi.org/10.2307/2296597

Wang, J.-H. (2007). From technological catch-up to innovation-based economic growth: South Korea and Taiwan compared. *The Journal of Development Studies*, *43*(6), 1084–1104. https://doi.org/10.1080/00220380701466609

Wang, Y., & Zhang, Z. (2025). Digital development and rural financial inclusion: Evidence from China. *Research in International Business and Finance*, *73*, Article 102637. https://doi.org/10.1016/j.ribaf.2024.102637

Xiong, D., Zhong, X., Sun, K., & Zhao, S. (2025). The Belt and Road Initiative and urban entrepreneurship: Evidence from the opening policy From China. *American Journal of Economics and Sociology*, *84*(3), 481–496. https://doi.org/10.1111/ajes.12614

Xu, S., Xu, Z., Guo, Z., & Wang, J. (2025). Can information infrastructure break the imbalance between urban and rural development? Empirical evidence from China. *Information Technology for Development*, *31*(1), 140–160. https://doi.org/10.1080/02681102.2024.2351729

Ye, L. (2025). Digital economy and high-quality agricultural development. *International Review of Economics & Finance*, *99*, Article 104028. https://doi.org/10.1016/j.iref.2025.104028

Yin, S., & Yuan, Y. (2024). Integrated assessment and influencing factor analysis of energy-economy-environment system in rural China. *AIMS Energy*, *12*(6), 1173–1205. https://doi.org/10.3934/energy.2024054

Yin, S., Wang, Y., & Zhang, Q. (2025). Mechanisms and implementation pathways for distributed photovoltaic grid integration in rural power systems: A study based on multi-agent game theory approach. *Energy Strategy Reviews*, *60*, Article 101801. https://doi.org/10.1016/j.esr.2025.101801

Yu, Z. (2024). Historical contribution of socialist political economy with Chinese characteristics. *Social Sciences in China*, *45*(3), 4–20. https://doi.org/10.1080/02529203.2024.2403262

Zhan, Y., Gao, D., Feng, M., & Yan, S. (2025). Digital finance, non-agricultural employment, and the income-increasing effect on rural households. *International Review of Financial Analysis*, *98*, Article 103897. https://doi.org/10.1016/j.irfa.2024.103897

Zhang, Y., & Qu, Y. (2024). Has the digital economy improved the consumption of poor and subsistence households?. *China Economic Review*, *83*, Article 102083. https://doi.org/10.1016/j.chieco.2023.102083

Zhao, T., & Duan, L. (2025). Digital transformation: how digital infrastructure impacts urban livability in China. *Applied Economics*, *58*(6), 1145–1161. https://doi.org/10.1080/00036846.2025.2464820

Zhou, C., & Li, B. (2023). How does e-commerce demonstration city improve urban innovation? Evidence from China. *Economics of Transition and Institutional Change*, *31*(4), 915–940. https://doi.org/10.1111/ecot.12361

Zhu, K., & Guo, L. (2024). Financial technology, inclusive finance and bank performance. *Finance Research Letters*, *60*, Article 104872. https://doi.org/10.1016/j.frl.2023.104872

Zong, Z., & Guan, Y. (2025). AI-driven intelligent data analytics and predictive analysis in Industry 4.0: Transforming knowledge, innovation, and efficiency. *Journal of the Knowledge Economy*, *16*(1), 864–903. https://doi.org/10.1007/s13132-024-02001-z