Spatial Effects of Digital Infrastructure Development on Common Prosperity: Empirical Evidence from Prefecture-Level Panel Data

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Abstract. As global digitization accelerates, a nation's digital infrastructure advancement has emerged as a crucial measure of its overall competitiveness, substantially contributing to premium socioeconomic growth and shared prosperity. This research analyzes the effect of digital infrastructure growth on shared prosperity, utilizing panel data from 280 Chinese cities (2008–2021) and a Spatial Durbin Model framework. The results show that digital infrastructure development significantly enhances local common prosperity levels, while its spatial spillover effects on neighboring regions are weak and negative, potentially exacerbating regional development imbalances. Further analysis reveals that digital infrastructure indirectly promotes common prosperity by fostering financial agglomeration and driving industrial structure upgrading. Based on these findings, this paper proposes policy recommendations to strengthen digital infrastructure development, optimize financial resource allocation, promote industrial structure upgrading, and enhance regional coordination to reduce regional disparities and achieve the goal of common prosperity.

Keywords: Digital Infrastructure Development, Common Prosperity, Spatial Durbin Model, Financial Agglomeration, Industrial Structure Upgrading.

1. Introduction

Amid the accelerating global digital transformation, digital infrastructure has become a crucial driver of economic growth and social progress. As the world's largest economy in terms of digital infrastructure scale, China exhibits significant regional disparities in the distribution of digital resources among its prefecture-level cities, forming a "dense in the east, sparse in the west" core-periphery pattern. Despite China’s leading position in digital infrastructure construction and digital economy development, the digital divide between regions remains evident. Data from 2022 shows that the 5G base station density in eastern prefecture-level cities reached 12.4 stations per square kilometer, which is 3.7 times higher than that in the western region. The standard deviation of fiber optic coverage exceeded 5.73, significantly surpassing the regional disparities in traditional infrastructure distribution [1].

As a fundamental goal of socialism with Chinese characteristics, achieving common prosperity faces challenges in narrowing income and public service gaps across urban and rural areas, regions, and social groups. Digital infrastructure serves as a material foundation for achieving common prosperity by promoting economic growth, optimizing resource allocation, and facilitating coordinated regional development [2]. However, its spatial spillover effects remain controversial. The spatial spillover effect typically refers to the influence exerted by a region's economic activities, policies, or technological changes on neighboring regions. Specifically, the construction and development of digital infrastructure not only directly promote local economic growth but may also generate positive or negative externalities for surrounding regions through mechanisms such as technology diffusion, talent mobility, and industrial chain synergies. Therefore, investigating the spatial spillover effects of digital infrastructure on common prosperity holds significant theoretical and practical importance.

While prior research has examined the nexus between digital infrastructure development and shared prosperity, several research gaps persist in the literature.First, most studies rely on provincial-level data, which has limited sample sizes and makes it difficult to capture the spatial effects at the prefecture level accurately. Second, previous research primarily focuses on the direct impact of digital infrastructure on local economic development, neglecting its spillover effects and transmission mechanisms on neighboring regions [3].

To address these gaps, this paper introduces the following innovations:

(1) Adoption of the Spatial Durbin Model (SDM): This model captures both the direct effects of digital infrastructure on common prosperity and its spatial spillover effects, providing a more comprehensive research perspective.

(2) Use of Prefecture-Level City Panel Data: Using panel data from 280 prefecture-level cities in China from 2008 to 2021, this study constructs a comprehensive evaluation system including the level of common prosperity (Compro), the level of digital infrastructure development (Diit), and the level of rural revitalization through digital development (DRR). Compared to provincial-level data, prefecture-level data offers richer spatial information, improves model estimation accuracy, and better reflects regional spatial correlations.

2. Theoretical Analysis and Hypotheses

2.1. The Direct Impact of Digital Infrastructure on Common Prosperity

Common prosperity, as a fundamental objective of socioeconomic progress, is significantly facilitated by digital infrastructure through three key mechanisms: optimizing resource distribution, fostering interregional development coordination, and reducing urban-rural income disparities [4]. It improves information transmission efficiency and reduces transaction costs, optimizing the allocation of production factors and driving economic growth and income increases for residents [5]. In particular, in rural areas, the development of digital infrastructure effectively bridges the "digital divide," reducing the urban-rural income gap [6].

Empirical studies indicate that digital infrastructure not only boosts local economies but also generates significant spatial spillover effects by facilitating the flow of innovation factors to neighboring regions, promoting regional economic coordination, and alleviating regional disparities.

Overall, digital infrastructure fosters economic growth by driving technological innovation, enhancing human capital, and lowering transaction costs. Additionally, it promotes balanced regional development and common prosperity by reducing regional disparities and improving income distribution.Based on this, the paper proposes the following hypothesis:

H1: Digital infrastructure development has a significant positive impact on common prosperity levels and exhibits spatial spillover effects.

2.2. The Indirect Impact of Digital Infrastructure on Common Prosperity

The rapid development of digital infrastructure provides crucial technological support for financial agglomeration, thereby having a profound impact on the realization of common prosperity. By offering high-speed, stable network connectivity and big data processing capabilities, digital infrastructure enhances the efficiency and coverage of financial services, facilitating the concentration of financial resources [7]. Financial agglomeration promotes regional economic coordination by optimizing resource allocation, reducing transaction costs, and improving service efficiency [8]. Digital infrastructure accelerates the transmission and sharing of financial information and drives innovation in financial technology, thus ensuring the success of financial agglomeration [9]. Through enhancing resource allocation efficiency, financial agglomeration helps to narrow the urban-rural gap, stimulate economic growth, and contribute to the realization of common prosperity [10]. Based on this, the paper proposes the following hypothesis:

H2: The construction of digital infrastructure creates the technological conditions for financial agglomeration, indirectly promoting common prosperity.

Industrial structure upgrading is propelled by digital infrastructure construction through enhanced information transmission, reduced transaction costs, and optimized factor allocation [11]. With fast and reliable network connectivity, digital infrastructure facilitates the digital and intelligent transformation of traditional industries, improving industrial efficiency and technological capabilities. This leads to the growth of emerging industries, especially high-tech sectors and modern services, further accelerating the overall optimization of the industrial structure [12]. Industrial structure upgrading not only stimulates economic growth but also creates more employment opportunities, boosting residents' income levels [13]. In the context of significant urban-rural income disparities, structural optimization promotes urban-rural economic integration, helping to reduce income gaps and support common prosperity [14]. Additionally, the digitalization of industries and structural improvements enhance resource allocation efficiency, promote regional economic coordination, and mitigate regional development imbalances. Therefore, digital infrastructure plays a key role in advancing common prosperity by driving industrial structure upgrading, which not only boosts income but also enhances social welfare, promoting equity and inclusiveness. Based on this, the following hypothesis is proposed:

H3: Digital infrastructure development, by promoting industrial structure upgrading, indirectly enhances the level of common prosperity.

Figure 1 presents the analytical framework of the impact mechanism proposed in this study.

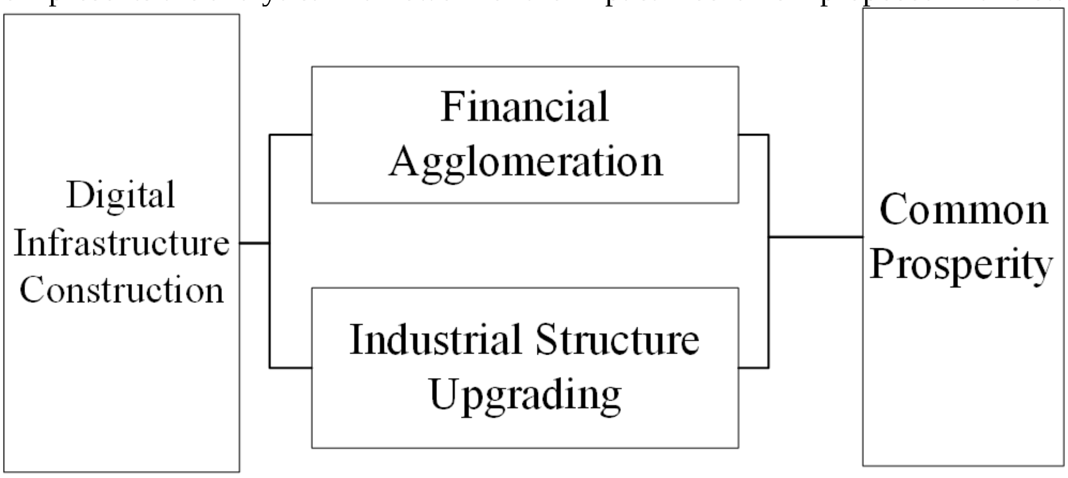

Figure 1. Analysis of the Impact Mechanism

3. Research Design

3.1. Model Specification

3.1.1.Spatial Durbin Model (SDM)

To systematically analyze the impact of digital infrastructure construction on common prosperity and its spatial spillover effects, this study constructs the Spatial Durbin Model (SDM). This model can simultaneously capture the spatial dependencies of both explanatory and dependent variables, making it suitable for analyzing the direct impact of digital infrastructure on common prosperity and its spatial spillover effects on neighboring regions. The specific form of the model is as follows:

$$\text{Compro}_{it} = c_i + \rho W \text{Compro}_{it} + \beta_1 \text{Diit}_{it} + \theta_1 W \text{Diit}_{it} + \beta_2 X_{it} + \theta_2 W X_{it} + \mu_i i + \gamma_t + \epsilon_{it} \quad (1)$$

Where:

i denotes the city, and t represents the year.

Compro_{it} indicates the level of common prosperity in city i at time t.

Diit_{it} represents the level of digital infrastructure construction in city i at time t.

X_{it} is the vector of control variables, including human capital level (HC), education level (Edu), and government intervention (FISC).

c_i is the constant term.

ρ signifies the spatial lag parameter, capturing the spatial autocorrelation in the dependent variable.

W corresponds to the spatial connectivity matrix.

β_1 and β_2 indicate the estimated parameters for core explanatory variables and control variables, respectively.

θ_1 and θ_2 measure the spatial spillover effects of explanatory variables and control variables, correspondingly.

μ_i and γ_t stand for city-specific and time-period fixed effects, controlling for unobserved spatial and temporal heterogeneity.

ϵ_{it} represents the stochastic disturbance term.

3.1.2.Mediation Effect Model

This study implements a mediation analysis to disentangle the pathways by which digital infrastructure construction (Diit) impacts common prosperity (Compro), specifically testing financial concentration (Finc) and industrial transformation (ISU) as potential mediators. The formal model specification appears below:

$$\mathrm{Finc}_{it} = \gamma_0 + \gamma_1 \mathrm{Diit}_{it} + \sum \gamma_n \mathrm{Control}_{it} + \omega_{it} \tag{2}$$

$$\mathrm{ISU}_{it} = \gamma_0 + \gamma_1 \mathrm{Diit}_{it} + \sum \gamma_n \mathrm{Control}_{it} + \omega_{it} \tag{3}$$

Where:

Finc_{it} t and ISU_{it} represent the financial agglomeration level and the industrial structure upgrading level of city *i* in year *t*, respectively.

Diit_{it} denotes the level of digital infrastructure construction in city *i* at time *t*.

$\mathrm{Control}_{it}$ represents the control variables.

γ_0 is the constant term.

γ_1 is the coefficient measuring the effect of digital infrastructure construction on financial agglomeration and industrial structure upgrading.

ω_{it} denotes the random error term.

3.1.3.Selection of Spatial Weight Matrix

In spatial econometric analysis, the selection of a spatial weight matrix significantly influences the model results. Traditional studies often employ spatial adjacency matrices to define the adjacency relationships between spatial units. However, in this study, as the data cover 280 prefecture-level cities in China and exclude certain cities (e.g., due to missing data or outliers), some cities do not share adjacency relationships, resulting in a spatial adjacency matrix with numerous zero values. In such cases, the spatial adjacency matrix fails to accurately capture the spatial correlations between cities, potentially leading to biased model estimations.

To address this issue, this study employs a geographical distance weight matrix to define the spatial relationships between cities. Specifically, the elements w_{ij} of the geographical distance weight matrix w are defined as follows:

$$w_{ij} = \frac{1}{d_{ij}^2} \tag{4}$$

Where:

d_{ij} denotes the geographical distance (in kilometers) between city *i* and city *j*.The geographical distance weight matrix effectively captures spatial relationships between cities, especially when city distribution is uneven.

3.2. Variable Definitions

3.2.1.Dependent Variable

The level of common prosperity (Compro) serves as the core dependent variable in this study. Common prosperity involves both achieving affluence and promoting equality. Based on its theoretical connotation, this study constructs an evaluation index system for common prosperity from the dimensions of affluence and sharing, with careful consideration of the quantifiability of indicators and data availability. The entropy weight method is employed for measurement. The detailed index system is presented in Table 1.

Table 1. Evaluation Index System for Measuring Common Prosperity

Dimension	Criterion Layer	Indicator Layer	Unit	Calculation Method	Attribute	Weight
Affluence	Material Affluence	Per Capita GDP	Yuan/year	Regional GDP / Regional Permanent Population	Positive (+)	0.1043
		Urban Disposable Income per Capita	Yuan	Total Urban Disposable Income / Urban Permanent Population	Positive (+)	0.0813
		Rural Disposable Income per Capita	Yuan	Total Rural Disposable Income / Rural Permanent Population	Positive (+)	0.1007
	Spiritual Affluence	Books per Capita	Thousand copies	Regional Library Collection / Regional Permanent Population	Positive (+)	0.2984
		Digital Internet Development	Households	Number of International Internet Users	Positive (+)	0.3070
Sharing	Income Distribution Gap	Urban-Rural Income Ratio	%	Urban Disposable Income per Capita / Rural Disposable Income per Capita	Negative (-)	0.0088
	Human Development	Medical Beds per Capita	Beds	Number of Hospital and Health Center Beds / Registered Population	Positive (+)	0.0707
		Aging Population Rate	%	Population Aged 65 and Above / Total Population	Negative (-)	0.0004
		Urbanization Rate	%	Urban Registered Population / Total Registered Population	Positive (+)	0.0282

3.2.2.Core Explanatory Variable

The level of digital infrastructure construction (Diit) is the core explanatory variable in this study. Drawing on relevant literature and considering data availability, this study constructs an evaluation index system for the level of digital infrastructure construction from two dimensions: digital infrastructure investment and digital infrastructure output . The entropy weight method is employed to measure the level of digital infrastructure construction. Details are presented in Table 2.

Table 2. Evaluation Index System for the Level of Digital Infrastructure Construction

Dimension	Indicator Layer	Unit	Calculation Method	Attribute	Weight
Digital Infrastructure Investment	Per Capita Internet Broadband Access Ports	Units/10,000 people	Internet Broadband Access Ports / Total Population	Positive (+)	0.352
	Proportion of Related Employees	%	Employment share in ICT sectors (defined as information transmission, computer services & software industries)	Positive (+)	0.235
Digital Infrastructure Output	Mobile Phone Penetration Rate	%	Subscribers/Population	Positive (+)	0.287
	Internet Penetration Rate	%	Internet Broadband Users / Total Population	Positive (+)	0.126

3.2.3.Mechanism Variable

Financial Agglomeration (Finc) refers to the concentration of financial institutions, talent, and activities in a specific region, driving economic development through economies of scale, synergies, and knowledge spillovers. A key indicator of financial agglomeration is the ratio of financial industry employees to total employees in a prefecture-level city (F/E), reflecting the proportion of financial talent in the regional economy.

Industrial Structure Upgrading (ISU) is the shift from low value-added, low-tech industries to high value-added, high-tech industries. It is often shown by the increasing share of the tertiary industry's added value and advancements in the secondary industry's technology and efficiency. The ratio of the added value of the tertiary industry to the secondary industry is used to measure ISU.

3.2.4.Control Variables

To avoid bias and accurately examine the relationship between digital infrastructure and common prosperity, this study includes the following control variables:

(1) Government Intervention (FISC): The ratio of fiscal expenditure to GDP.

(2) Human Capital Level (HC): The proportion of college and university students in the total population.

(3) Education Level (Edu): The proportion of regional education expenditure to total government budget.

3.3. Data Sources and Description

Based on data availability, this study selects panel data from 280 prefecture-level and above cities in China for the period 2008–2021. The relevant data are primarily sourced from the China Statistical Yearbook, China City Statistical Yearbook, China Regional Statistical Yearbook, and provincial/municipal statistical yearbooks for the corresponding years. For missing data in certain years, the linear interpolation method is employed to estimate and ensure data completeness. Descriptive statistics for the variables are presented in Table 3.

Table 3. Descriptive Statistics of Variables

Variable	Variable Description	Sample Size	Mean	Standard Deviation	Minimum	Maximum
Compro	Level of Common Prosperity	3920	0.1146	0.0563	0.011	0.4900
Diit	Level of Digital Infrastructure Construction	3920	0.1441	0.1302	0.0001	2.3369
Finc	Financial Agglomeration	3920	0.0393	0.0197	0.0012	0.2998
ISU	Industrial Structure Upgrading	3920	1.0031	0.5728	0.1386	5.3482
HC	Human Capital Level	3920	0.0199	0.0259	0.0000	0.1777
Edu	Education Level	3920	0.1783	0.0412	0.0000	0.3774
FISC	Government Intervention	3920	0.1931	0.1042	0.0426	1.4851

4. Empirical Analysis

4.1. The Impact of Digital Infrastructure Construction on Common Prosperity

4.1.1.Spatial Correlation Test

Table 4 presents the results of the spatial correlation test for digital infrastructure development and common prosperity in 280 prefecture-level cities from 2008 to 2021. Using the geographic distance matrix, the Moran's I values for both variables are negative and statistically significant at the 1% level, indicating the presence of spatial correlation. This suggests that employing spatial econometric methods for analysis is appropriate.

Table 4. Moran's I for Digital Infrastructure Construction and Common Prosperity in 280 Prefecture-Level Cities (2008–2021)

Year	Digital Infrastructure Construction	Common Prosperity	Year	Digital Infrastructure Construction	Common Prosperity
2008	-0.014^{***}	-0.026^{***}	2015	-0.019^{***}	-0.026^{***}
2009	-0.015^{***}	-0.031^{***}	2016	-0.022^{***}	-0.024^{***}
2010	-0.013^{***}	-0.026^{***}	2017	-0.020^{***}	-0.029^{***}
2011	-0.018^{***}	-0.030^{***}	2018	-0.015^{***}	-0.028^{***}
2012	-0.022^{***}	-0.031^{***}	2019	-0.013^{***}	-0.028^{***}
2013	-0.022^{***}	-0.027^{***}	2020	-0.012^{***}	-0.030^{***}
2014	-0.022^{***}	-0.027^{***}	2021	-0.013^{***}	-0.031^{***}

Notes:
(1) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
(2) The same notation applies to subsequent tables.

4.1.2.Selection of Spatial Econometric Model

Table 5. Test Results for Spatial Econometric Model Selection

Test Method	Test Indicator	Statistic
LR Test	LR-lag	96.66^{***}
	LR-error	27.56^{***}
Hausman Test	Hausman test	282.45^{***}
LR Fixed Effects Test	LR-spatial fixed effects	589.77^{***}
	LR-time fixed effects	6324.79^{***}

After confirming spatial correlation, further tests were conducted to select the appropriate model. The results are presented in Table 5. The findings show that the Likelihood Ratio (LR) test results are significant, rejecting the null hypothesis that the Spatial Durbin Model (SDM) degenerates into the Spatial Autoregressive Model (SAR) or the Spatial Error Model (SEM) at the 1% significance level. Additionally, the Hausman test results are significant, indicating that the fixed-effects Spatial Durbin Model should be selected. The LR fixed-effects test results are also significant. Based on these results, this study employs a double fixed-effects Spatial Durbin Model for empirical analysis.

4.1.3.Regression Results

Table 6 presents the regression results for different models. Column (1) shows the results without control variables, Column (2) displays the results with control variables added, and Column (3) provides the results for the Spatial Durbin Model (SDM).

Table 6. Regression Results of Different Models

Variable	(1)	(2)	(3)
Diit	0.2800*** (67.63)	0.2581*** (61.76)	0.0725*** (27.46)
HC	-	0.2837*** (4.67)	-0.0334 (-1.20)
Edu	-	-0.1046*** (-5.27)	0.0251** (2.69)
FISC	-	0.1158*** (11.92)	-0.0434*** (-8.61)
W× Diit	-	-	-0.0536 (-1.67)
W× HC	-	-	4.1016*** (6.88)
W× Edu	-	-	-0.6483*** (-5.24)
W× FISC	-	-	0.0782*** (3.01)
Spatial rho	-	-	-2.0483*** (-11.50)
Obs	3920	3920	3920
R^2	0.6056	0.5188	0.2181
Log-likelihood	-	-	11973.4110

The analysis confirms that digital infrastructure construction (Diit) has a significantly positive impact on common prosperity (Compro) across all models, supporting Hypothesis H1.

However, SDM regression results alone do not fully capture the relationship between digital infrastructure and common prosperity. To address this, the study applies the partial differential method to decompose the spatial spillover effects into total, direct, and indirect effects . The decomposition results are shown in Table 7.

Table 7. Decomposition of Effects

Variable	Direct Effect	Indirect Effect	Total Effect
Diit	0.0725***	-0.0536	0.0189
HC	-0.0334	4.1016***	4.0682***
Edu	0.0251**	-0.6483***	-0.6232***
FISC	-0.0434***	0.0782***	0.0348

The results of the spatial decomposition effect indicate that digital infrastructure development has a significant positive impact on local common prosperity, while its effect on the common prosperity of neighboring regions is relatively weaker.

4.1.4.Robustness Test

To ensure the robustness of the results, this study substitutes the core explanatory variable (Diit) with its first-order lag term (L1_Diit) and re-estimates the model. The findings indicate that the lagged effect of digital infrastructure construction continues to have a significantly positive impact on common prosperity, further supporting the robustness of the conclusions. Table 8 displays the regression results from the Spatial Durbin Model, used for the lag term robustness test.

Table 8. Robustness Test Results (Lag Term)

Variable	Direct Effect	Indirect Effect	Total Effect
L1_Diit	0.0339***	-0.0380	-0.0041
HC	0.0496	3.2057***	3.2553***
Edu	0.0265**	-0.4316***	-0.4051***
FISC	-0.0408***	0.0866***	0.0458*

The regression results indicate that Diit has a significantly positive effect on both Finc (coefficient=0.0183***) and ISU (coefficient=1.2053***), thereby validating Hypothesis H2 (the financial agglomeration pathway) and Hypothesis H3 (the industrial upgrading pathway).

4.2. Mechanism Test

The regression results of digital infrastructure construction's effects on financial agglomeration and industrial structure upgrading are presented in Table 9.

Table 9. Effects of Digital Infrastructure on Financial Agglomeration and Industrial Upgrading

Variable	Finc Coefficient	t-value	ISU Coefficient	t-value
Diit	0.0183***	6.35	1.2053***	9.93
HC	-0.0001	-0.01	7.2160***	15.76
Edu	-0.0767***	-8.80	0.2378	1.35
FISC	0.0186***	5.37	2.7082***	18.04
Constant	0.0467***	23.56	0.1204**	2.43
Observations	3920		3920	
R^2	0.0598		0.3710	

Therefore, Hypothesis H2—that digital infrastructure construction indirectly promotes the level of common prosperity by fostering financial agglomeration—and Hypothesis H3—that digital infrastructure construction indirectly enhances the level of common prosperity by driving industrial structure upgrading—are both supported.

5. Conclusions and Recommendations

This study uses panel data from 280 prefecture-level cities in China from 2008 to 2021, applying the Spatial Durbin Model and the Mediation Effect Model to empirically examine the impact of digital infrastructure construction on common prosperity and its underlying mechanisms. The results indicate that digital infrastructure construction significantly enhances common prosperity within the local region. However, its spatial spillover effects on neighboring regions are weak and negative, suggesting that while digital infrastructure directly promotes regional development, its spillover may widen regional disparities.

Further mediation analysis reveals that digital infrastructure construction indirectly advances common prosperity by fostering financial agglomeration and driving industrial structure upgrading. Financial agglomeration supports common prosperity by optimizing capital allocation efficiency and enhancing financial service quality. Meanwhile, industrial structure upgrading boosts economic efficiency and increases the share of high value-added industries, further contributing to common prosperity.

Based on these findings, this paper offers the following policy recommendations:

Expand Digital Infrastructure Construction: Prioritize development in less developed regions to bridge the digital divide and promote balanced regional growth.

Optimize Financial Resource Allocation: Encourage financial agglomeration and support the growth of small and medium-sized enterprises (SMEs) and rural development.

Promote Industrial Upgrading: Support the digital transformation of traditional industries to improve economic efficiency and foster high value-added industries.

Strengthen Regional Collaboration: Mitigate the negative spatial spillover effects of digital infrastructure by enhancing resource sharing and fostering coordinated regional development.

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