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Digital Empowerment and Spatial Equilibrium: An Empirical Examination of the Impact of the Digital Economy on Regional Economic Patterns from the Perspective of Common Prosperity

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Abstract

Common prosperity is an important goal of China's high-quality development. Optimizing the spatial layout of the regional economy and guiding rational economic agglomeration are key to advancing coordinated regional development. The digital economy is profoundly reshaping regional economic patterns, but its mechanisms of influence on prefecture-level economic spatial agglomeration still require clarification. Based on panel data from 266 prefecture-level cities in China from 2010 to 2023, this paper constructs a comprehensive digital economy index and employs two-way fixed effects and the Spatial Durbin Model to examine the impact of the digital economy on regional economic agglomeration and its spatial spillover effects. The results show that the digital economy significantly strengthens local economic agglomeration, with even stronger spatial spillover effects, exhibiting a regional siphoning phenomenon. This impact varies significantly across different locations, city types, and development levels. All three types of moderating factors positively enhance local agglomeration levels but inhibit positive spatial spillovers and exacerbate regional imbalances. This study provides empirical evidence for formulating location-specific digital development policies and promoting coordinated regional development.

Keywords

digital economy, regional economic spatial distribution agglomeration, common prosperity, Spatial Durbin Model, moderating effect

1. Introduction

1.1 Research Background and Significance

Common prosperity is the essential requirement and long-term goal of socialism with Chinese characteristics. Narrowing regional development gaps and promoting coordinated regional development constitute its key pathways. Against the backdrop of global digital transformation, the digital economy has become a core driving force for China's high-quality economic development and the reshaping of regional economic patterns. Data

elements have profoundly altered traditional resource allocation methods. Existing research has mostly focused on the relationship between the digital economy and regional disparities at the national and provincial levels. However, there is insufficient research on prefecture-level cities—the pivotal link between upper and lower administrative levels. The level of digital economy development in prefecture-level cities directly determines the effectiveness of coordinated regional development on the ground. Therefore, it is urgently necessary to explore the impact and underlying logic of the digital economy on the degree of regional economic spatial agglomeration at the prefecture-level city scale. This forms the core background and starting point of this study.

This research holds important theoretical and practical value. Theoretically, it broadens the research boundaries of the spatial effects of the digital economy by incorporating multiple moderating variables to explore the intrinsic relationship between the digital economy and regional economic patterns. In practice, it can provide references for various regions to formulate location-specific digital economy development policies and optimize resource allocation. It also offers empirical support for promoting coordinated regional development and advancing the realization of common prosperity.

1.2 Literature Review

1.2.1 Current Research Status on the Digital Economy and Regional Economic Spatial Distribution Agglomeration

The digital economy is a new economic form that takes data resources as key production factors, modern information networks as the main carriers, and the integrated application of information and communication technologies along with the digital transformation of all factors as important driving forces. It has become a core force driving China's high-quality economic development, reshaping industrial patterns, and promoting social progress. Current academic methods for measuring the digital economy exhibit diversified characteristics. For example, Pan Kai [1] used the entropy weight method to construct a provincial digital economy index. Zhang Mingyuan et al. [2] employed the entropy weight method and analytic hierarchy process from the perspective of internet development's impact on manufacturing efficiency. Huang Qunhui et al. [3] selected five indicators to measure the level of digital economy development. Chao Xiaojing et al. [4] used the vertical and horizontal scatter degree method to construct an index system from dimensions such as platformization and intelligentization. Meanwhile, scholars such as Zhang Liao et al. [5] measured the scale of inter-city data flows from the perspective of data factor mobility, emphasizing that cross-regional data flows can break traditional geographical constraints.

At the empirical level, Yang Yan [6] used panel data from 30 Chinese provinces (2010–2021) and found that the synergistic agglomeration of commerce and trade circulation and manufacturing exerts a nonlinear impact on the regional economy. Yuan Minglu et al. [7], based on urban panel data from 2007–2023, confirmed that economic agglomeration significantly enhances local fiscal capacity. Zhao Jianmei [8], using prefecture-level city panel data and continuous nighttime light data from 2000–2019 and adopting an instrumental variable–fixed effects approach, studied the impact of marketization on regional economic imbalances.

1.2.2 The Impact of the Digital Economy on Regional Economic Spatial Distribution Agglomeration

Existing research shows that the impact of the digital economy on regional economic spatial agglomeration exhibits dual characteristics.

Most studies support the view that the digital economy intensifies regional economic agglomeration. Yao Changcheng et al. [9] found that the digital economy promotes economic polarization through siphoning effects. Zuo Wanshui et al. [10], based on prefecture-level city data, confirmed that digital economy innovation exhibits spatial imbalance. At the same time, some empirical studies have reached opposite conclusions, showing that under certain conditions the digital economy can relieve agglomeration pressure, weaken spatial polarization, and reduce regional development imbalances. For example, Xu Zhenyu et al. [11], through inter-provincial panel data analysis, found that due to its strong permeability and broad coverage, the digital economy can extend public services to small and medium-sized cities, alleviate excessive agglomeration, and provide important momentum for promoting coordinated and balanced regional economic development.

1.2.3 Literature Commentary

A comprehensive review of existing literature reveals that research on the digital economy and regional economic agglomeration has accumulated rich achievements, but obvious deficiencies remain, providing room for expansion in this paper. First, the refinement of digital economy measurement needs improvement. Many existing studies focus on the provincial level and struggle to capture intra-prefecture heterogeneity. This paper therefore selects data from 266 prefecture-level cities nationwide to enhance the precision of the research scale and the reliability of conclusions. Second, there is a disconnect between research perspectives and policy objectives. Existing literature rarely directly and systematically examines the countervailing effect whereby the digital economy intensifies economic agglomeration and widens regional imbalances. Attention to the polarization effects and negative spatial effects of the digital economy is insufficient. Most studies emphasize its growth effects while neglecting its negative impacts on spatial equilibrium. Third, the analysis of mechanisms and spatial effects needs deepening, with insufficient exploration of nonlinear characteristics and moderating mechanisms. This paper will further deepen the above analyses and provide new perspectives and references for related research.

1.3 Research Objectives

Against the background of promoting common prosperity and leveraging the characteristics of the high-speed development of the digital economy, this paper focuses on the real challenge of unbalanced regional economic development. It examines the mechanisms and actual effects of the digital economy on regional economic spatial agglomeration, aiming to provide solid theoretical foundations and reliable empirical support for resolving regional development imbalances and achieving high-quality coordinated development, thereby better serving the implementation of the common prosperity goal. Specifically, the research objectives of this paper are as follows: to explore the mechanisms through which the digital economy influences regional economic spatial distribution agglomeration, analyze the transmission pathways of its spatial spillover effects, and elucidate the internal logic of how the digital economy acts on coordinated regional development and assists in realizing common prosperity. Through heterogeneity analysis and moderating effect tests, the paper examines the differentiated impacts of the digital economy on regional economic spatial agglomeration, further identifies key mechanisms, and provides data support and empirical evidence for optimizing regional resource allocation and strengthening regional collaborative governance, thereby assisting the steady realization of the common prosperity goal.

1.4 Innovations and Limitations

The innovations of this paper are mainly concentrated in three aspects: (1) using 266 prefecture-level cities as the research sample to accurately depict urban spatial correlations and heterogeneity; (2) with multi-dimensional grouping tests based on location, city type, and city hierarchy to comprehensively reveal differentiated impacts and enhance the practical value of the conclusions; (3) in terms of indicator measurement, constructing a multi-dimensional comprehensive indicator system and using the entropy weight method to calculate the comprehensive digital economy index, avoiding the limitations of single indicators and improving the scientific rigor of variable measurement. This study still has some limitations: First, the data ends in 2023, making it difficult to reflect the latest industry developments, and missing data for some cities slightly affects empirical precision. Second, the study only examines the effects of individual moderating variables separately and does not explore interactive synergistic relationships among variables, resulting in insufficiently comprehensive mechanism analysis.

2. Research Hypotheses on the Impact of the Digital Economy on Regional Economic Spatial Distribution Agglomeration

2.1 Spillover Effects of the Digital Economy on Regional Economic Spatial Distribution Agglomeration

The digital economy is characterized by high permeability and cross-temporal and spatial interactivity. Its influence extends beyond local areas and affects neighboring regions through spatial correlation channels [14]. On the one hand, the development of the digital economy in central cities may attract high-quality factors such

as capital and talent from surrounding areas to core regions through a "siphoning effect," leading to a relative decline in the economic status of neighboring areas and intensifying spatial imbalance [15]. On the other hand, given the significant geographical and economic spatial correlations among Chinese prefecture-level cities, the polarizing effect of the digital economy often has spillover boundaries. Through industrial chain linkages and demonstration effects, it forms specific growth poles or disparity zones within geographically proximate areas [16].

Hypothesis 1: The digital economy index has a significant spatial spillover effect on the degree of regional economic spatial distribution agglomeration in prefecture-level cities.

2.2 Research on the Moderating Effects of the Digital Economy on Regional Economic Spatial Distribution Agglomeration

The driving process of the digital economy on regional economic agglomeration does not occur in isolation but is deeply coupled with the regional institutional environment, financial support, and fiscal backing.

Cities with a higher degree of openness can more smoothly integrate into global digital value chains, absorb international advanced technology spillovers, and enhance the competitiveness of local digital industries. High-level opening-up not only attracts foreign investment into digital sectors but also strengthens cities' hub functions as regional economic nodes through cross-border data flows, thereby amplifying the positive effect of the digital economy on spatial agglomeration [17]. Based on this, the paper proposes:

Hypothesis 2A: The level of opening-up positively moderates the relationship between the digital economy and regional economic spatial agglomeration.

Finance serves as the driving force behind digital transformation. A higher level of financial development can effectively alleviate financing constraints faced by digital enterprises in R&D investment and improve resource allocation efficiency. When the regional financial environment is favorable, the digital economy can be more efficiently converted into actual productive forces, further consolidating the economic leading position of core cities [18]. Based on this, the paper proposes:

Hypothesis 2B: The level of financial development positively moderates the relationship between the digital economy and regional economic spatial agglomeration.

Fiscal expenditure on science and technology has significant guiding and leverage effects. The government bridges shortcomings in digital infrastructure through science and technology spending and supports research on key technologies, providing essential public goods for the digital economy to empower the real economy. In regions with strong government support for science and technology, the positive driving force of the digital economy on regional economic centrality will be further strengthened [19]. Based on this, the paper proposes:

Hypothesis 2C: The level of government science and technology expenditure positively moderates the relationship between the digital economy and regional economic spatial agglomeration.

3. Spatial Spillover Effect Analysis of the Digital Economy on Regional Economic Spatial Distribution Agglomeration

To investigate the impact of the digital economy on regional economic spatial agglomeration, this paper takes 266 prefecture-level cities in China from 2010 to 2023 as the research sample. The data are sourced from the China City Statistical Yearbook of relevant years and the statistical yearbooks of various prefecture-level cities. After excluding cities with unavailable data, a balanced panel dataset is constructed for a series of analyses.

3.1 Variable Selection and Data Description

Based on the preceding analysis, this paper selects the following variables and corresponding measurement methods.

3.1.1 Core Explained Variable: Regional Economic Spatial Agglomeration (udg)

Drawing on the regional theoretical framework of Cai Fang et al. [20], this paper uses the ratio of a city's per capita GDP (in 10,000 RMB) to the national per capita GDP (in 10,000 RMB) to measure the degree of

spatial agglomeration and centrality of each prefecture-level city's economic activities at the national level. This paper denotes regional economic spatial agglomeration as Udg, with the specific calculation formula shown in Equation (3.1).

$$\text{Udg}=\frac{GDP_{it}}{GDP_{national,t}}\times 10^4 \tag{3.1}$$

where GDP_{it} represents the gross regional product of city i in year t (unit: 100 million RMB), and $GDP_{national,t}$ represents the national GDP in year t (unit: 100 million RMB).

This ratio reflects the relative position of a single city's economic scale within the national economy. A higher ratio indicates a stronger central position of the city in the national economy, a greater tendency toward economic agglomeration in spatial distribution, and a more concentrated economic pattern. This indicator captures the static distributional characteristics of regional economic patterns and serves as a core foundational variable for studying balanced regional development.

3.1.2 Core Explanatory Variable: Digital Economy Index (dei)

Most studies measure the digital economy index (Dei) by constructing multi-dimensional indicator systems. Based on the 14th Five-Year Plan for Digital Economy Development, which divides the digital economy into two core components—"digital industrialization" and "industrial digitalization"—while treating "digital infrastructure" as the foundational support, many scholars follow this three-dimensional framework to design indicators. Building on the above research and considering data availability, this paper constructs a four-dimensional evaluation system comprising 18 indicators to assess the digital economy level of cities. The entropy method is adopted to determine the weight of each indicator and calculate the digital economy index for each city. Table 1 reports the comprehensive evaluation system for urban digital economy constructed in this paper.

Table 1: The comprehensive evaluation system for urban digital economy

Dimension	Indicator	Indicator Direction
Digital Infrastructure	Internet Broadband Access Rate	+
	Long-distance Optical Cable Line Density	+
	Number of Base Stations	+
	Number of Domain Names	+
Digital Industrialization	Mobile Phone Penetration Rate	+
	Number of Enterprises in Information Transmission, Software and Information Technology Service Industry	+
	Proportion of Employees in Information Transmission, Software and Information Technology Service Industry	+
	Number of Domestic Patent Applications Granted	+
	Number of Domestic Patent Applications Accepted	+
Industrial Digitalization	Peking University Digital Financial Inclusion Index	+
	E-commerce Sales Volume	+
	Added Value of the Secondary and Tertiary Industries	+
	R&D Expenditure	+
	Postal Business Volume	+
Data Element Flow	Number of International Internet Users	+
	Profits of Industrial Enterprises above Designated Size	+
	Scale of Mobile Phone Facilities	+
	Per Capita Total Telecommunications Business	+

3.1.3 Control Variables and Moderating Variables

This paper selects the following factors, other than the digital economy, that influence regional economic agglomeration. These mainly include:

Government intervention level (Gi), industrial structure level (Isl), human capital level (Hc), infrastructure level (Infra), marketization index (Mi), economic development speed (Eds), urbanization level (Urban), government education expenditure level (Ee), and medical and health level (Mh).

The moderating variables selected in this paper are:

Level of opening-up (Oul), financial development level (Fd), and government science and technology expenditure level (St).

3.2 Spatial Characteristic Analysis of the Digital Economy on Regional Economic Distribution Agglomeration

3.2.1 Introduction to the Spatial Weight Matrix

This paper constructs a spatial geographical weight matrix W_1. Based on the latitude and longitude coordinates of each city, the Euclidean distance d_{ij} between their centroids is calculated. Considering that spatial interaction decays with increasing distance, the matrix elements are set as the inverse square of the distance, as specifically expressed in Equation (3.2).

$$w_{ij}^{g}=\begin{cases}1/d_{ij}^{2}, & i\neq j\\ 0, & i=j\end{cases} \tag{3.2}$$

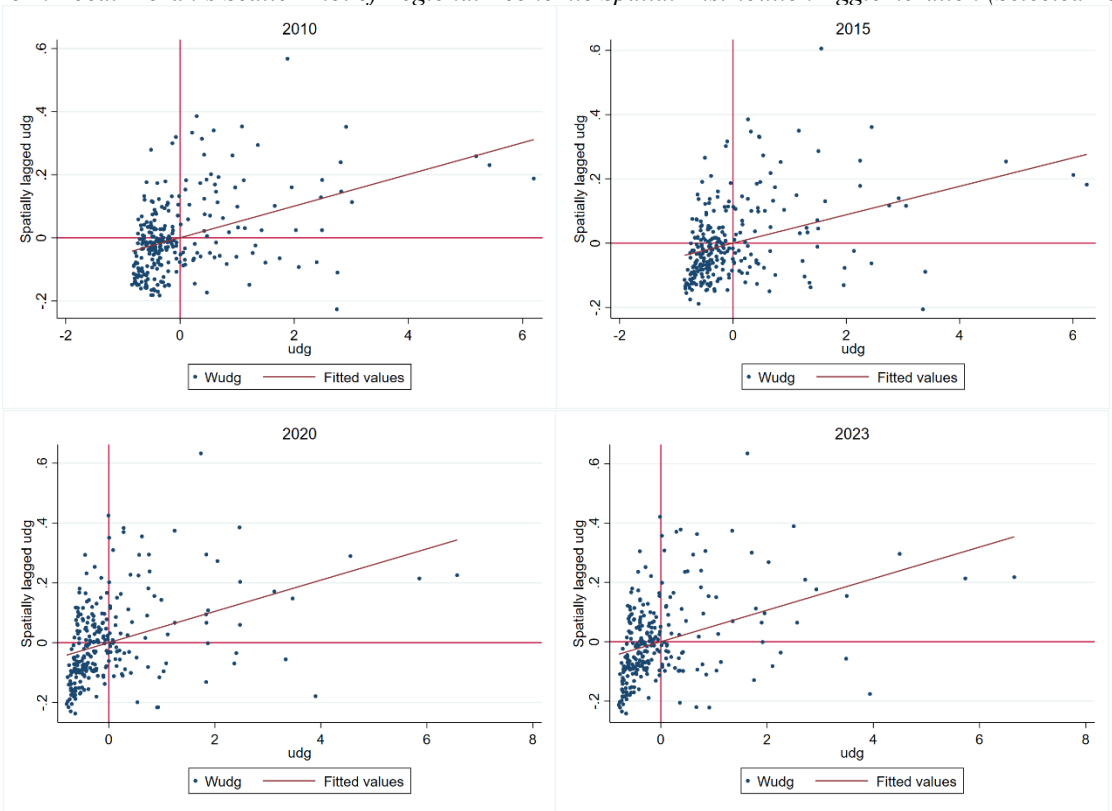
Followed by row standardization of the matrix.

3.2.2 Spatial Autocorrelation

To ensure the reasonableness of the spatial econometric model specification, a spatial autocorrelation test must be conducted before empirical regression to verify whether the variables exhibit spatial dependence. Using the spatial geographical weight matrix, this paper performs a spatial autocorrelation analysis on the regional economic spatial distribution agglomeration (Udg) of 266 prefecture-level cities in China from 2010 to 2023. The results show that the global Moran's I index for Udg in each prefecture-level city across all years is significantly positive at the 1% level. This indicates that economic agglomeration among prefecture-level cities exhibits significant positive spatial correlation and overall presents a clear pattern of spatial agglomeration.

To further examine the local heterogeneity of regional economic spatial distribution agglomeration (Udg) in its dynamic evolution, this paper selects four time points—2010, 2015, 2020, and 2023—to plot the Local Moran's I scatter diagrams (Figure 1).

Figure 1: Local Moran's Scatter Plot of Regional Economic Spatial Distribution Agglomeration (Selected Years)



The analysis results show that most city sample points are stably distributed in the first quadrant (high-high agglomeration) and the third quadrant (low-low agglomeration). This intuitively confirms that China's prefecture-level city economic development exhibits significant "local club agglomeration" characteristics. Core urban agglomerations have formed leading high-value agglomeration areas through resource exchange, while the majority of non-core prefecture-level cities have fallen into contiguous low-level development zones.

3.3 Model Testing and Selection

Having established that the variables exhibit significant spatial correlation, this paper follows the principle of moving from general to specific and conducts a series of statistical tests to determine the most appropriate spatial panel model specification. Lagrange Multiplier (LM) tests, LR tests, and Wald tests were performed. The test results support the construction of the Spatial Durbin Model (SDM), which provides more comprehensive coverage of effects.

The Hausman test was also conducted to determine whether the model should use fixed effects or random effects. The test result shows that the traditional Hausman statistic is –47.36 (negative value). Referring to the Monte Carlo simulation conclusions of Lian Yujun et al. [22], the negative Hausman statistic primarily arises from endogeneity correlation between explanatory variables and individual effects, which is common in city-level panel data. This result strongly rejects the null hypothesis that random effects are superior, indicating that random effects estimation suffers from endogeneity bias, while fixed effects estimation is more robust. In the LR test, the two-way fixed effects model and the individual fixed effects model did not pass conventional significance tests. Although the statistic is insignificant, considering that national digital economy strategies and other macro policies during the sample period may exert strong common shocks across cities, and that test power is easily limited in high-degree-of-freedom environments, the two-way fixed effects model is adopted to minimize omitted variable bias and in line with common practice in regional economic research.

Therefore, this paper selects the two-way fixed effects Spatial Durbin Model for regression analysis. The specific expression of the model used in this paper is shown in Equation (3.3).

$$udg_{it}=\rho\sum_{j=1}^{N}w_{ij}udg_{jt}+\beta_1 dei_{it}+\beta_2 Control_{it}+\theta_1\sum_{j=1}^{N}w_{ij}dei_{jt}+\theta_2\sum_{j=1}^{N}w_{ij}Control_{it}+\mu_i+\gamma_t+\varepsilon_{it} \tag{3.3}$$

where $\sum_{j=1}^{N}w_{ij}udg_{jt}$ is the spatial lag term of the core explained variable, $\sum_{j=1}^{N}w_{ij}dei_{jt}$ is the spatial lag term of the core explanatory variable, ρ is the spatial autocorrelation coefficient (reflecting the degree and direction of spatial dependence of the explained variable), θ_1 is the coefficient of the spatial lag of the core explanatory variable, and θ_2 is the coefficient vector of the spatial lags of the control variables.

3.4 Empirical Results

Based on the series of tests described above, this paper conducts regression analysis using the two-way fixed effects Spatial Durbin Model.

Table 2: Baseline Regression Results

VARIABLES	(1) Main	(2) Wx	(3) Direct	(4) Indirect	(5) Total
dei	23.55***	167.2***	22.86***	77.86***	100.7***
	(2.531)	(38.16)	(2.564)	(18.45)	(18.26)
gi	-0.414***	-0.961**	-0.414***	-0.315	-0.729***
	(0.0242)	(0.394)	(0.0206)	(0.224)	(0.222)
infra	4.597***	44.30***	4.435***	21.78***	26.21***
	(0.681)	(11.75)	(0.741)	(7.239)	(7.261)
isl	-0.108***	-0.469	-0.104***	-0.212	-0.317
	(0.0220)	(0.386)	(0.0242)	(0.235)	(0.232)
hc	-0.615***	-0.466	-0.644***	-0.0435	-0.687
	(0.143)	(2.461)	(0.168)	(1.255)	(1.262)
mi	0.0909	-1.593	0.107	-0.732	-0.624
	(0.172)	(2.732)	(0.166)	(1.374)	(1.367)
ee	-0.232***	-5.060***	-0.211***	-2.580***	-2.791***

VARIABLES	(1) Main	(2) Wx	(3) Direct	(4) Indirect	(5) Total
	(0.0457)	(0.816)	(0.0466)	(0.468)	(0.466)
mh	1.482	17.19	1.196	8.800	9.997
	(1.566)	(23.00)	(1.403)	(11.99)	(11.90)
rho	-0.917***				
	(0.199)				
sigma2_e		19.05***			
		(0.443)			
Observations	3,724	3,724	3,724	3,724	3,724
R-squared	0.147	0.147	0.147	0.147	0.147
Number of cityid	266	266	266	266	266

Table 2 reports the benchmark estimation results of the impact of the digital economy on regional economic spatial distribution agglomeration under the spatial geographical distance weight matrix. The results show that both the direct coefficient of the digital economy index (Dei) (23.55) and the spatial lag coefficient (167.2) are significantly positive at the 1% level. This indicates that the development of the digital economy not only directly enhances the agglomeration of the local economic pattern but also exhibits strong positive spatial spillover characteristics. The rapid digital advancement in neighboring cities generates a significant siphoning effect on the local area, further strengthening the position of core cities by capturing high-efficiency factors across regions and widening the positional gaps between regions. In addition, the spatial autoregressive coefficient is significantly negative (–0.917). Under the setting of this study, this reflects that when the economic agglomeration in surrounding areas increases, the local economic agglomeration relatively declines, further confirming the intensity of spatial competition and the existence of the siphoning effect. Thus, Hypothesis 1 is verified.

3.5 Robustness Tests

To verify the reliability of the results regarding the impact of the digital economy on regional economic spatial distribution agglomeration, this paper conducts robustness checks from multiple dimensions, including endogeneity treatment, sample screening, and variable replacement.

3.5.1 One-Period Lag of the Independent Variable

Considering the time-lag effect of digital economy development on regional economic spatial distribution agglomeration and potential endogeneity arising from two-way causality between the core explanatory and explained variables, this paper lags the core explanatory variable (Dei) by one period and substitutes it into the two-way fixed effects Spatial Durbin Model. All other control variables and model specifications remain consistent with the baseline regression.

3.5.2 Excluding Provincial Capital Samples

The baseline regression sample includes 266 prefecture-level cities. As regional political, economic, and cultural centers, provincial capital cities exhibit significant differences from non-capital prefecture-level cities in both digital economy development levels and regional economic spatial agglomeration. This heterogeneity may affect the generalizability of the conclusions. Therefore, this paper excludes all provincial capital cities from the sample, retaining only non-capital prefecture-level cities, and re-estimates using the two-way fixed effects Spatial Durbin Model.

3.5.3 Replacing the Explained Variable

To avoid bias caused by the measurement method of the explained variable (Udg), this paper follows the robustness testing approach from the previous chapter's baseline regression and uses nighttime light intensity (Nli) as an alternative measure of regional economic spatial distribution agglomeration.

In summary, across the three dimensions of robustness tests, both the direct and indirect effects of the digital economy index remain significantly positive at the 1% level, consistent with the baseline regression conclusions. This indicates that the core empirical findings of this paper are reliable and robust.

3.6 Heterogeneity Analysis

This paper further divides the full sample into groups along three dimensions, geographical location, city attribute, and city hierarchy, and conducts heterogeneity tests to clarify the differentiated impacts of the digital economy on the spatial agglomeration of regional economic distribution.

3.6.1 Heterogeneity Across Four Major Geographical Regions

Considering the unbalanced nature of China's regional economic development, the polarizing effect of the digital economy may be related to economic location and policy orientation. To further examine the spatial heterogeneity characteristics of the impact of digital economy development (Dei) on regional economic spatial agglomeration (Udg), this paper divides the sample into four major geographical regions: Eastern, Central, Western, and Northeastern, and performs group-wise empirical comparisons.

Table3 shows that the coefficient for the Eastern region is 11.49 (significantly positive), while the coefficients for the Central and Western regions are 37.56 and 66.03, respectively—both significantly larger than that of the Eastern region. The coefficient for the Northeastern region is –169.7 (significantly negative), indicating that digital economy development instead promotes regional balance, which aligns closely with the characteristics of the transformation stage of the old industrial bases in Northeast China.

Table 3: Heterogeneity Test Results of the Four Major Geographical Regions

VARIABLES	Eastern Region		Central Region		Western Region		Northeastern Region	
	(1) Main	(2) Wx	(3) Main	(4) Wx	(5) Main	(6) Wx	(7) Main	(8) Wx
dei	11.49***	27.83	37.56***	-9.352	66.03***	43.38	-169.7***	89.12
	(1.887)	(30.67)	(1.981)	(36.76)	(2.156)	(35.94)	(5.528)	(102.3)
rho	-0.738***		-0.363**				-1.112***	
	(0.185)		(0.161)				(0.218)	
sigma2_e		5.993***		1.199***				3.920***
		(0.139)		(0.0278)				(0.0914)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.402	0.402	0.000	0.000	0.463	0.463	0.500	0.500

3.6.2 Resource-Based Vs. Non-Resource-Based Cities

Differences in resource endowments across cities affect their industrial structures and capacity to absorb digital technologies. Resource-based cities are typically highly dependent on traditional energy and heavy industry, while non-resource-based cities often have more dynamic industrial structures. Based on this, the sample is divided into resource-based and non-resource-based cities for group regressions.

The study finds significant polarization in the spatial effects of the digital economy between the two types of cities. According to the regression results in Table 4, the coefficient for resource-based cities is significantly negative (–15.37), indicating that digital economy development inhibits regional economic agglomeration in these cities, exhibiting a certain decentralizing characteristic. This may be because digital technology applications in resource-based cities focus more on efficiency optimization across the entire industrial chain rather than agglomeration toward a few core cities. In contrast, the coefficient for non-resource-based cities is 30.02, significantly positive at the 1% level. This shows that in non-resource-based cities, the digital economy exhibits a strong agglomeration orientation, more readily attracting high-end factors such as capital, technology, and talent to core cities, thereby forming industrial clusters centered on core cities and reinforcing the "core-periphery" structure of economic space. This may, to some extent, intensify the agglomeration of economic distribution within regions.

Table 4: Heterogeneity Test Results of Resource-Based vs. Non-Resource-Based Cities

VARIABLES	Resource-Based Cities		Non-Resource-Based Cities	
	(1)	(2)	(3)	(4)
	Main	Wx	Main	Wx
dei	-15.37***	6.382	30.02***	26.56
	(3.105)	(57.61)	(2.110)	(33.02)
rho	-0.781***		-2.044***	
	(0.201)		(0.225)	

VARIABLES	Resource-Based Cities		Non-Resource-Based Cities	
	(1)	(2)	(3)	(4)
	Main	Wx	Main	Wx
sigma2_e		8.305***		9.950***
		(0.193)		(0.234)
Controls	Yes	Yes	Yes	Yes
R-squared	0.226	0.226	0.059	0.059

3.6.3 Heterogeneity by City Hierarchy

City hierarchy comprehensively reflects core dimensions such as economic scale, resource endowments, and development foundations. Different hierarchical levels of cities show significant differences in digital infrastructure construction, industrial digital transformation, and regional radiation capacity. This paper classifies Level-1 cities as developed cities, Levels 2–4 as relatively developed cities, and Level-5 cities as less developed cities, and conducts group regressions.

The results in Table 5 show that the impact exhibits a significant U-shaped pattern, with direct and indirect effects differing markedly across city hierarchies. Developed and less developed cities demonstrate strong spatial radiation capacity, while the relatively developed cities in the middle tiers become trough areas in effect transmission.

Table 5: Heterogeneity Test Results of City Hierarchy

VARIABLES	Developed Cities		Relatively Developed Cities		Less Developed Cities	
	(1) Main	(2) Wx	(3) Main	(4) Wx	(5) Main	(6) Wx
dei	54.61*** (3.473)	-86.95 (55.83)	-3.878 (4.297)	34.65 (77.07)	27.52*** (4.216)	94.41 (79.49)
rho	-0.704*** (0.189)		-1.024*** (0.203)		-0.851*** (0.194)	
sigma2_e		4.815*** (0.112)		12.09*** (0.281)		0.830*** (0.0193)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.007	0.007	0.236	0.236	0.578	0.578

4. Analysis of the Moderating Mechanisms of the Digital Economy's Impact on Regional Economic Spatial Distribution Agglomeration

The effect of the digital economy on economic agglomeration does not occur in isolation but is deeply intertwined with external conditions such as opening-up, financial development, and government science and technology expenditure. Opening-up determines a city's ability to integrate into global digital value chains and acquire external resources. Financial development provides capital support for digital industry agglomeration, while government science and technology expenditure offers public guarantees for digital innovation and infrastructure. All three factors may strengthen the local agglomeration effect of the digital economy, alter the direction of its spatial spillovers, and thereby amplify or constrain the "core-periphery" spatial structure.

To this end, this chapter introduces three moderating variables into the Spatial Durbin Model, constructs a spatial moderating effect model, and examines the moderating mechanisms of the external environment on the spatial effects of the digital economy, thereby refining the theoretical logic of its influence on regional economic patterns.

4.1 Model Construction

Building upon the two-way fixed effects Spatial Durbin Model, this paper introduces moderating variables and their interaction terms with the digital economy, while also incorporating the spatial lag terms of the interaction terms, to construct a spatial moderating effect model. The specific form is shown in Equation (4.1).

$$udg_{it} = \rho \sum_{j=1}^{N} w_{ij} udg_{jt} + \beta_1 dei_{it} + \beta_2 Mod_{it} + \beta_3 Dei_{it} \times Mod_{it} + \theta_1 \sum_{j=1}^{N} w_{ij} dei_{jt} + \theta_2 \sum_{j=1}^{N} w_{ij} Mod_{it} + \theta_3 \sum_{j=1}^{N} w_{ij} Dei_{it} \times Mod_{it} + \sum_{k=1}^{N} \delta_k Control_{kit} + \sum_{k=1}^{N} \varphi_k \sum_{j=1}^{N} w_{ij} Control_{kjt} + + \mu_i + \gamma_t + \varepsilon_{it} \quad (4.1)$$

where Mod_{it} represent the level of opening-up, financial development level, and government science and technology expenditure level, respectively; $Dei_{it} \times Mod_{it}$ terms represent the coefficients of the local interaction terms (capturing local moderating effects); and $\sum_{j=1}^{N} w_{ij} Dei_{it} \times Mod_{it}$ terms represent the coefficients of the spatial lag terms of the interaction terms (capturing spatial spillover moderating effects). The meanings of other variables and coefficients are the same as in Equation (3.3).

4.2 Moderating Mechanisms of the Digital Economy on Regional Economic Spatial Distribution Agglomeration

This paper examines the moderating roles of opening-up level (Oul), financial development level (Fd), and government science and technology expenditure level (St) in the process by which the digital economy influences regional economic spatial distribution agglomeration.

4.2.1 Level of Opening-up (oul)

From the perspective of direct effects, the coefficient of the interaction term between the digital economy and the level of opening-up (44.60) is significantly positive. This indicates that as a city's degree of opening-up increases, the promotional effect of the digital economy on local economic agglomeration is significantly strengthened, making it easier to form a centralized pattern.

In addition, the direct effect coefficient of the opening-up level (Oul) itself is significantly positive, suggesting that higher regional openness directly promotes the agglomeration of production factors and exerts a positive effect on local economic agglomeration. Based on this, Hypothesis 2A is supported.

4.2.2 Level of Financial Development (fd)

From the direct effect perspective, the coefficient of the interaction term is 5.806 and significant at the 1% level. This means that financial development positively moderates the impact of the digital economy on local economic agglomeration. In cities with more developed financial systems, digital factors can be more rapidly transformed into capital momentum, attracting high-end industries and production factors to converge further toward core cities. Cities with high financial development leverage their strong capital allocation capabilities in the digitalization process, generating a pronounced "spatial siphoning" effect. This cumulative effect does not produce widespread diffusion but instead may deprive surrounding areas of growth opportunities, further widening the gap between centers and peripheries. This suggests that, from the perspective of national overall layout, the combination of financial development and the digital economy exhibits a strong non-equilibrium orientation at the present stage. While it improves local efficiency, it inhibits the optimization of the overall economic pattern at the national level. Based on this, Hypothesis 2B is supported.

Table 6: Moderation Effect Test Results

VARIABLES	Level of Opening-up		Level of Financial Development		Level of Government Science and Technology Expenditure	
	(1) Main	(2) Wx	(1) Main	(2) Wx	(1) Main	(2) Wx
dei	9.378***	288.0***	-6.825	411.2***	-2.020	368.7***
	(3.153)	(50.72)	(7.902)	(126.3)	(4.940)	(72.96)
dei_oul	42.25***	-376.0***				
	(5.660)	(97.21)				
dei_fd			5.438***	-51.82**		
			(1.372)	(23.14)		
dei_st					2.095***	-29.22***
					(0.546)	(8.718)

VARIABLES	Level of Opening-up		Level of Financial Development		Level of Government Science and Technology Expenditure	
	(1) Main	(2) Wx	(1) Main	(2) Wx	(1) Main	(2) Wx
oul	3.242***	37.39***				
	(0.594)	(9.400)				
fd			-2.204***	-7.469**		
			(0.164)	(3.257)		
st					0.874***	2.105
					(0.0968)	(1.472)
rho	-1.010***		-1.164***		-0.881***	
	(0.201)		(0.209)		(0.196)	
sigma2_e		18.08***		18.06***		18.14***
		(0.421)		(0.421)		(0.422)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.216	0.216	0.025	0.025	0.078	0.078

4.2.3 Level of Government Science and Technology Expenditure (st)

Government science and technology expenditure (St), as an important policy tool for guiding digital technology innovation and factor allocation, plays a significant positive moderating role in the process by which the digital economy influences regional economic spatial agglomeration. As shown in the table 6, the estimated coefficient of the interaction term is 2.095 and significantly positive at the 1% level. This likely indicates that in practice, government science and technology expenditures tend to tilt toward core cities with strong innovation foundations and well-developed industrial supporting systems. When combined with such policy resources, the digital economy further attracts high-end factors to core regions, amplifying agglomeration effects. Meanwhile, the indirect effect coefficient of the interaction term is significantly negative. At the spatial spillover level, science and technology investment strengthens the economic centrality of core cities and intensifies the siphoning effect on surrounding areas. Based on this, Hypothesis 2C is supported.

5. Conclusions and Policy Recommendations

5.1 Research Conclusions

Based on panel data from 266 prefecture-level cities in China from 2010 to 2023, this paper constructs indicator systems for the digital economy index and regional economic spatial distribution agglomeration. Using the two-way fixed effects Spatial Durbin Model, along with mediating and moderating effect models, it systematically investigates the impact of the digital economy on regional economic patterns. The main conclusions are as follows:

First, the digital economy significantly intensifies regional economic agglomeration. Its indirect effect is approximately three times the direct effect, exhibiting a pattern of “core-periphery” solidification.

Second, heterogeneity is pronounced: the polarizing effect is prominent in the Eastern region, while the Northeastern region shows a balancing effect; non-resource-based cities exhibit strong agglomeration effects, whereas resource-based cities show decentralization; the effect across city hierarchies follows a “U-shaped” pattern.

Third, opening-up, financial development, and government science and technology expenditure all positively moderate local agglomeration. However, they exhibit negative interaction effects in the spatial spillover dimension, intensifying the resource squeeze from centers on peripheries.

5.2 Policy Recommendations

Based on the above research conclusions, to mitigate the polarizing burden of the digital economy, narrow regional development gaps, and support the realization of the common prosperity goal, this paper proposes the following policy recommendations:

First, build a regional coordinated development system, optimize factor allocation, and bridge the digital divide. Establish cross-regional digital economy systems and encourage regions to promote intra-regional collaborative governance through technology spillovers and industrial chain extensions.

Second, implement differentiated policies tailored to heterogeneous characteristics. In the Eastern region and developed areas, guide high-quality development of the digital economy while strengthening radiation and driving effects. In the Northeastern region, leverage digital technology to empower traditional industries and promote regional balance. Non-resource-based cities should continue advancing digital economy development, while resource-based cities should use digital technology for industrial transformation. For cities of different hierarchies, precisely match digital economy development priorities to enhance policy effectiveness.

Third, regulate the pathways of moderating factors and prevent spatial alienation. Improve the level of opening-up in prefecture-level cities and establish cross-regional opening-up coordination mechanisms. Improve financial services for the digital economy and guide financial resources to tilt toward less developed cities. Optimize the structure of government science and technology expenditures, establish science and technology resource sharing mechanisms, and promote the transfer and transformation of research outcomes to support balanced regional development.

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Conflicts of Interest

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