Digital Economy, Spatial Agglomeration of Distribution Industry and Regional Economic Growth

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Abstract. Digitalization has transformed traditional business models and expanded economic activity. This paper studies the impact of regional digital development on growth and discusses the moderating role of distribution industry agglomeration. It offers insights for informationization and a new perspective on digital development's impact on regional growth.

Keywords: Digital economy; spatial agglomeration of the distribution industry; regional economic growth.

1 Introduction

The digital economy has become important in promoting China's economic development. The continuous acceleration of digital transformation has further accelerated the continuous penetration of modern information technologies such as mobile Internet, big data and artificial intelligence in traditional industries. It has greatly subverted and innovated the traditional business model and format and expanded the space of modern economic activities, making production, consumption and product distribution no longer completely dependent on traditional geographical distance. Based on this, this paper investigates the effect of regional digital development on regional economic growth and further discusses the moderating role spatial agglomeration of the distribution industry plays.

2 Literature Review

2.1 Digital Economy and Regional Economic Development

The Internet-led digital economy is globally transforming production and consumption patterns[12]. Literature often discusses concepts like e-economy and information economy. Studies focus on regional structural transformations due to digitalization[11]. In China, research has developed index systems to measure digital economy development, focusing on infrastructure, applications, and industry development[9]. Research on digital economy benefits emphasizes employment quality and efficiency, innovation performance, and economic growth. Studies show that industrial intelligence enhances

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employment structure quality and digital environments improve employment efficiency[15]. Innovation efficiency exhibits positive spatial externalities, and the digital economy has direct and spillover effects on it, though these effects vary by region and innovation subject[8,14]. Additionally, ICTs like mobile phones and Internet use drove economic growth in Middle Eastern, North African, and sub-Saharan African developing countries from 2007 to 2016[1].

2.2 Digital Economy and Spatial Agglomeration of Distribution Industry

The literature on spatial agglomeration of the distribution industry in the digital economy is limited but expanding. Key studies include Driffield et al. highlighting its role in industry comparative advantage and foreign investment[2]. Zhao et al. [18] discussed China's digital transformation, while Ye et al.[17] examined the digital economy's relationship with tourism. Wang et al.[16] focused on ICT co-agglomeration's impact on carbon productivity in China. Further research investigated how the digital economy promotes the geographical agglomeration of the manufacturing industry in China, highlighting the significant positive effect of the digital economy on manufacturing agglomeration. Wang & Kang[13] explored the impact of the digital economy on industrial eco-efficiency, emphasizing the importance of environmentally friendly industry development. The existing literature suggests that the digital economy is crucial in promoting spatial agglomeration within various industries, including manufacturing, tourism, and information and communication technology. The studies underscore the need for further research to fully understand the dynamics of the digital economy's impact on spatial agglomeration and industry development.

2.3 Summarize and Comment

At present, the research literature on digital development is relatively novel. However, the content is not much, mainly focusing on its effect research, lacking research on its transmission mechanism and action principle. Moreover, the structural indicators of the digital and information development environment are different, and the measurement standards need to be determined. This paper explores whether the digital environment of the industry can play a role in regional economic development from a macro perspective and explores how the spatial agglomeration level of the distribution industry plays a regulatory role in it.

3 Theoretical Hypothesis

This paper establishes hypotheses based on economic growth and network externality theories. Economic growth theory focuses on factors like technological progress and capital that drive GDP increase[10]. Network externality theory states that increased network users enhance each user's utility, promoting scale economies, technological innovation, and industrial upgrading[6,7]. Economic growth theory and network

externality theory constitute an important driving force for the optimal allocation of resources and economic growth in a network economy.

In the digital economy, new production factors like knowledge, information, and data are growing in importance. As network scales expand, so does the market, drawing more users and enterprises. This forms a powerful network effect, reducing costs, improving efficiency, enhancing product/service quality, and optimizing user experience. In the digital environment, the distribution industry breaks geographical barriers due to network effects and decentralization. Digital development facilitates resource flows, enhancing the significance of digitalization in areas with poor spatial agglomeration. Thus, the distribution industry increasingly relies on digital advantages to promote regional economic growth. Therefore, this paper proposes the following hypotheses:

H1: Improving the regional digitalization level can significantly promote regional economic growth.

H2: The lower the level of industrial clusters in the distribution industry, the more obvious the promotion effect of digitalization development on regional economic growth.

4 Empirical Analysis

4.1 Variable Design

Digital Environment Measurement.

Combined with data availability, this paper decomposes the total index of the digital environment from two dimensions: digital foundation and digital popularization. The digitization foundation includes two secondary indexes: optical cable line density and mobile phone switch density. Digital popularization includes four secondary indicators: Internet broadband access density, broadband Internet user density, mobile phone penetration rate and mobile Internet user density. The indicators come from the statistical yearbooks of China and other provinces. See table 1 for the specific indicator system and description:

Table 1. Digital Environmental Index System

Main Index	Primary index	Secondary indicators (measurement indicators)	Indicator description
Digital environment	Digital foundation	Fibre optic line density	Length of optical cable line/population
		Mobile phone exchange density	Mobile telephone exchange capacity/population
	Digitalization popularization	Internet broadband access density	Internet broadband access ports/population
		Broadband Internet subscriber density	Internet broadband access users/population
		Mobile phone penetration rate	Direct data from the Statistical Yearbook
		Mobile Internet user density	Number of mobile Internet users/population

To facilitate analysis, indicators were standardized using the threshold method[3]. To ensure cross-year comparability of the digital environment index, this paper adapts Fan et al.'s marketization index methodology[4]. The base period is set to 2015, using traditional linear dimensionless methods for 2015 and a modified version for subsequent years, allowing for cross-year comparisons and reflecting progress or regression. This is specified as follows:

$$X_i = \frac{V_i - V_{min}}{V_{max} - V_{min}} \times 6 + 1 \tag{1}$$

$$X_i = \frac{V_{it} - V_{min0}}{V_{max0} - V_{min0}} \times 6 + 1 \tag{2}$$

V_i is the raw data of the measure, V_{max} is the maximum value of the raw data among the 30 provinces (except Hong Kong, Macao, Taiwan and Tibet, the same below), and V_{min} is the minimum value among the 30 provinces. t represents the year of the measure, and V_{max0} and V_{min0} represent the maximum and minimum values of the raw data in the base year, respectively. After the above treatment, measures become comparable across years. Non-base period scores may exceed 7 or fall below 1, reflecting digital economy development over time.

In terms of weight processing, this paper selects the NBI index weighting method for weighting processing, i.e.: (1) the weight of each level of indicator = 1/the number of indicators at that level; (2) the weight of each second-level indicator relative to the total index = the sub-weight of the second-level indicator * the sub-weight of the first-level indicator to which the indicator belongs. After determining the weights, a linear weighting method is used to calculate the digital environment index, and the formula can be expressed as follows:

$$\mathrm{DE_{it}} = \sum_{j=1}^{7} \mathrm{X_{it}} \times \mathrm{W_j} (\mathrm{j} = 1,\ 2,\ 3,\ 4,\ 5,\ 6) \tag{3}$$

In the above formula, j represents the standardized secondary index; W_j represents the weight of the j-th secondary index relative to the digital environmental index.

Spatial Agglomeration Level of Distribution Industry.

Location entropy measures factor distribution in a region, indicating industrial specialization and a region's role in a higher-level area[5]. The formula for calculating the locational entropy coefficient for the distribution industry is as follows:

$$LQ_{ij} = \frac{q_{ij}/q_i}{q_i/q} \tag{4}$$

In this formula, LQ_{ij} denotes the entropy of location of industry i in region i in the whole country, q_{ij} is the relevant index (e.g., output value, employment, etc.) of industry i in region j; q_j is the relevant index of all industries in region j; q_i refers to the relevant index of industry i in the whole country; q is the relevant index of all industries in the whole country. A higher location entropy coefficient means higher spatial agglomeration and specialization of the distribution industry in the region. This paper uses output

value of wholesale, retail, catering, accommodation, transportation, warehousing, and postal industries to measure the distribution industry.

Other Variable Designs.

In this paper, the digital environment is the main variable, spatial agglomeration of the distribution industry is the mediator, and GDP per capita & total GDP are explanatory variables. Control variables include industrial structure, financial development, foreign trade, and fiscal expenditure. Specific variable indicators are shown in Table 2:

Table 2. List of variable indicators

	Abbreviation	Variable name	Indicator description	Data source
	LnGDP	Regional Economic Level	Logarithm of GDP	China Statistical Yearbook
			Logarithm of GDP per capita	China Statistical Yearbook
Explained variable	DE	Digital Environment	Indicator system method construction	China Statistical Yearbook
	SAC	Spatial agglomeration of the distribution industry	Location entropy construction	China Statistical Yearbook
	DE*SAC	Digital Environment* Spatial Concentration of Distribution Industry	Cross-multiplication term	China Statistical Yearbook
Control variable	IS	Industrial Structure	Tertiary Industry Output / Secondary Industry Output	China Statistical Yearbook
	FD	Financial Development	Year-end balance of urban and rural residents' RMB savings deposits/GDP	China Statistical Yearbook, Wind database
	FT	Foreign Trade	Total amount of import and export of the location of business units/GDP	China Statistical Yearbook
	FE	Fiscal Expenditure	General budget expenditure of local finance/GDP	China Statistical Yearbook

4.2 Model

Basic Regression Model.

To test the impact of the digital environment and distribution industry agglomeration on the regional economy, this paper constructs a regression model to validate H1:

$$LnGDP_{it} = \alpha_0 DE_{it} + \alpha_1 IS_{it} + \alpha_2 FD_{it} + \alpha_3 FT_{it} + \alpha_4 FE_{it} + \varepsilon_{it} \quad (5)$$

Further Tests: Moderating Effects.

To test if distribution industry agglomeration moderates the relationship between the digital environment and regional economic development, this paper introduces a model to validate H2:

$$LnGDP_{it} = \alpha_0 DE_{it} + \alpha_1 SAC_{it} + \alpha_2 DE_{it} * SAC_{it} + \alpha_3 IS_{it} + \alpha_4 FD_{it} + \alpha_5 FT_{it} + \alpha_6 FE_{it} + \varepsilon_{it} \quad (6)$$

5 Results

5.1 Descriptive Statistics

As shown in Table 3, the maximum value of the digital environment indicator is 17.53, the minimum value is 2.052341, and its standard deviation is 2.8747; the breadth of this range is large; GDP per capita (this paper takes the logarithm) maximum value of 17.5322, the minimum value of 2.0523, all of these can fully reflect the digitalization level and the economic development of China's provinces there are some differences. In addition, the standard deviation of the distribution industry's spatial agglomeration level (SAC) is 0.1324, which is between 1.3113 and 0.7199, and the gap is relatively small. Among the control variables, the standard deviation of fiscal expenditure is small, while financial development, foreign trade level and industrial structure have large differences. The details are shown in Table 3:

Table 3. Results of descriptive statistics

Variable	average Value	Standard deviation	Minimum value	Maximum value
Per capita GDP	5.378986	2.874738	2.052341	17.53217
GDP	26917.78	21239.55	1847.7	107986.9
DE	5.378906	2.874738	2.052341	17.53217
SAC	0.9841911	0.1324467	0.7198738	1.311307
IS	1.387545	0.7554847	0.7042738	5.23404
FD	3.427432	1.027959	1.948503	7.035239
FT	4118.825	4088.85	185.2419	18456.81
FE	0.2651914	0 .1172163	0.1199702	0.7534361

5.2 Basic Regression Results

Table 4 shows digitization is positively related to regional economic development at the 1% level. Financial development, industrial structure, and fiscal expenditure also significantly impact economic development, proving H1 correct.

Table 4 Basic Regression Results

Variables	Coefficients
DE	0 .1583132***
	9.65
IS	-0.2634225***
	-4.06
FD	-0.1378807**
	-2.26
FT	-1.49e-06
	-0.13
FE	-4.615093***
	-10.92
Cons	11.0874 ***
	95.12
R-squared	0.8654
F	172.36

5.3 Group Inspection Results

To test if distribution industry agglomeration affects digitalization's promotion of regional economic development, this paper tests their multiplication term by grouping. Table 5 shows: high agglomeration weakens digitalization's impact, while low agglomeration enhances it. Thus, distribution industry agglomeration negatively regulates digitalization's positive effect on economic growth. High spatial agglomeration of the local distribution industry means close distance and refined labor division, reducing the need for digitization. Low agglomeration means long distance and low specialization, relying more on digital development to promote economic growth. Thus, H2 is verified.

Table 5. Results of the group test

Variables	Coefficients	
	High(1)	Low(2)
DE	0.0044827	0.1807361**
	0.01	2.06
SAC	-0.75143	1.044204
	-0.53	1.65
DE*SAC	0.0523901	-0.0002951
	0.15	-0.00
IS	-0.2753797	-0.0830226

	-1.26	-1.15
FD	-0.0161392	-0.3557721***
	-0.14	-5.19
FT	-7.34e-06	-1.92e-06
	-0.27	-0.18
FE	-4.864891***	-1.293818
	-5.49	-1.32
Cons	11.0874 ***	9.754367***
	8.53	13.95
R-squared	0.7290	0.8016
F	23.06	41.97

5.4 Robustness Test

This paper uses log per capita GDP to test main regression robustness, finding a significant positive correlation between the digital index and regional economic indicators at 5% and 10% confidence, confirming the regression's effectiveness.

6 Conclusions

Digital development boosts regional economies. Low-agglomeration areas rely more on digital environments for growth. Therefore, digital infrastructure should be improved and the digital economy developed to drive regional growth. In areas with weak distribution industries, accelerating digital technology can create a good digital environment, promoting industrial clustering and further regional growth.

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