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Digital Economy Empowerment and Value Chain Remodeling in the New Development Pattern of "Double Cycle"

-- The Yangtze River Delta City Cluster as an Example

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Abstract

At present, China is actively building a new development pattern of "double cycle". In this context, the digital economy based on data flow and technological innovation is developing rapidly, and the continuous integration and synergistic development between industries promotes the reshaping of China's value chain in the global value chain and its continuous extension to the high-end. This paper constructs a digital economy evaluation system based on the perspective of Yangtze River Delta cluster, measures the scale and spatial distribution of digital economy development in each city of Yangtze River Delta from 2014 to 2019 by entropy value method, and uses panel data regression model to study the influence of digital economy on the proportion of value added of secondary and tertiary industries to GDP. The results show that the level of traditional manufacturing and industrialization continues to decrease under the influence of digital economy, and the value added of the tertiary industry, mainly service industry, continues to increase, and the digital economy indeed reshapes and empowers the value chain, prompting the close integration of information technology and traditional manufacturing. Finally, the article proposes the realization path of digital economy empowerment and value chain reshaping from four aspects: policy mechanism, industry optimization, value chain end and internal and external circulation.

Keywords

Digital Economy; Value Chain Reshaping; Evaluation System; Yangtze River Delta; Entropy Method.

1. Introduction

At present, in the face of the international industrial chain supply chain instability, external demand shrinkage and international economic and trade frictions, the rise of trade protectionism of the severe economic situation, China is accelerating the construction of a domestic and international "double cycle" of the new development pattern, mainly domestic circulation. At the same time, the digital economy based on data flow and technological innovation is developing rapidly, accelerating the trade transformation and upgrading of enterprises and supporting economic development through the development model of "digital-driven development and innovation-led future". At present, the coordinated development and optimal layout and adjustment of industrial structure among cities in several major city clusters in China, exemplified by the Yangtze River Delta city cluster, are also accelerating the upgrading of China's position in the global value chain and promoting the reshaping of its digital economy

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value chain and its extension to the high-end of the global value chain. For digital economy empowerment and value chain reshaping, domestic academics have not given good measurements and model construction, while the relationship between the two has not been well thesis. Thus, we ask the question: Under the double-loop development pattern, what is the relationship between digital economy empowerment and value chain remodeling before? And what indicators are used to measure the association between the two? Can digital economy empowerment positively contribute to the reshaping of value chains and the formation of a double-loop development pattern? Based on the existing literature, this paper innovatively selects the Yangtze River Delta city cluster as the research perspective, and studies the scale and development trajectory of the digital economy of the Yangtze River Delta city cluster based on the entropy value method, and measures the scale of its digital economy development, while taking the calculated entropy value as the basis, combining with the data on the added value of secondary and tertiary industries in the Yangtze River Delta city cluster in recent years as a proportion of GPD and foreign trade data, to empirically prove that The relationship between digital economy empowerment, value chain reshaping and double-cycle pattern development in the Yangtze River Delta city cluster is studied.

In recent years, more domestic and foreign scholars have studied the digital economy-enabled value chain reshaping and the formation of double-loop development pattern separately, but not many of them have combined to study the intrinsic relationship in one piece. The concept of value chain was originally proposed by economist Michael E. Porter in 1985, and is defined as a group of organized groups that divide labor to carry out a series of economic activities, thereby creating value for customers. This theory explains well the process of business value generation, value addition and transformation, and is the basis of traditional value chain theory. Later, Peter Hines (Peter Hines) subsumed information technology into auxiliary production activities and believed that the integration and development of consumers, technology development and markets formed, thus, the industrial value chain. This is a subversion and innovative thinking for the traditional value chain.

The theories of traditional value chains are based on the background that the digital economy is not yet mature and the global traditional manufacturing industry is developing rapidly. With the rapid development of digital economy based on digital technology and big data flow, more and more developing countries have started to pay attention to the construction of digital economy-related infrastructure and the release of related policies. The new value chain theory is urgently needed to better link the digital economy empowerment with the value chain development, and promote the extension of China's value chain to the high value end and the high quality development of the economy.

Currently, the digital economy empowerment is continuing. In terms of digital economy empowerment value chain, previous authors have mainly studied two aspects, namely mechanism construction, realistic path and effect measurement and analysis. Li Xiaohua and Wang Yifan (2020) analyzed three aspects of the value creation mechanism, influencing factors, and connotation and characteristics of the data value chain [1]. Ying Qiu and Zhouming Guo (2019) analyzed the current situation and dilemma of SMEs climbing along the value chain, the existing theoretical basis and mechanism, and sequentially proposed a realistic path for the digital economy to drive SMEs to value climbing [2]. Similarly, Jinhai Xu and Jiechang Xia (2020) and Zhouming Guo and Ying Qiu (2020) both propose Chinese strategies for related value chain upgrading [3-4]. Jun'e Zhang (2021) studies the relationship between digital trade and global value chain reshaping, and further proposes realistic paths in four aspects: infrastructure construction, policy mechanism, risk prevention and control, and industrial development to provide ideas for accelerating the development of digital trade and reshaping the value chain [5]. And He Wenbin (2020) analyzed the development dynamics and evolution trend of China's manufacturing digitalization by using relevant data and models, and analyzed the

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transformation and upgrading of manufacturing brought by digitalization from another perspective [6]. Yuan Kaihua et al. (2021) draw on the dual strengths of value-added trade and micro-measurement to integrate data to construct an analytical framework on domestic value chains and new trade theories related to them [7].

In summary, the existing scholars' research rooms on digital economy empowerment, value chain remodeling and double-loop development pattern are separated and mainly developed from the national level, and there is less research literature on digital economy empowerment value chain remodeling under the double-loop development pattern in each province (city and autonomous region). At the same time, the results of the analysis using most of them are limited to statistical measurements and comparative descriptions, and no further research and theoretical elaboration of the relationship between the two is done. Compared with previous studies, the contributions of this paper may be: (1) to construct the inner connection and growth relationship between digital economy empowerment and value chain remodeling based on the perspective of urban clusters, and to analyze the inner law and theoretical connection using entropy value method and linear regression equation. (2) Analyze the formation of digital economy empowerment double-loop development pattern from the perspective of value chain reshaping. It can provide suggestions for governments at all levels to formulate policies that are consistent with economic and social development, digital transformation of enterprises and value chain reshaping in the context of double-cycle development policies, and contribute to the construction of the double-cycle pattern.

2. Model Construction and Data Description

2.1. Model Setting

In order to test the effect of digital economy on the share of value added in the secondary industry to GDP and the share of value added in the tertiary industry to GDP, we construct the following panel data regression model.

$$y_{it} = \sum_{k=1}^{K} \beta_{ki} x_{kit} + u_{it} (i = 1, 2..., N; t = 1, 2..., T)$$

where y_{it} is the value of the explanatory variable for individual i at time t, x_{kit} is the value of the kth non-random explanatory variable for individual i at time t, β_{ki} is the parameter to be estimated, and u_{it} is the random error term.

2.2. Selection of Indicators

Considering that there are no specific statistics on the scale of digital economy by government departments, in terms of the selection of specific indicators, based on previous studies, we refer to the design of its indicator system, while taking into account the availability of data indicators, we select four indicators: total telecommunication business, number of cell phone subscribers, number of mobile Internet subscribers, number of employed persons in urban units_information transmission, software and information technology service industry to measure the scale of digital economy and analyze whether the digital economy has empowered value chain reshaping by studying the impact of digital economy on the share of value added of secondary and tertiary industries in GDP. The article selectively selects the data of the three provinces and one city in the Yangtze River Delta region from 2014 to 2019 based on the statistical database of the China Economic Network and the China Statistical Yearbook.

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Table 1. Table of Digital Economy Indicators

Nature of Indicator	Specific indicators	Description of Meaning
Digital Economy Indicators	Total telecom business (billion yuan)	Number of communication services
	Number of cell phone subscribers (million)	Cell phone penetration
	Number of mobile Internet users (million)	Mobile Internet penetration
	Number of employed persons in urban units_Information transmission, software and information technology service industry (10,000 persons)	Scale of information service industry development

2.3. Data Description

For the evaluation of the quality of digital economy development in the Yangtze River Delta city cluster, we selected four indicators to measure the scale of digital economy: total telecommunication services, number of cell phone subscribers, number of mobile Internet subscribers, number of employed persons in urban units_information transmission, software and information technology service industry. Among them, total telecom services and cell phone subscribers can indirectly reflect the level of infrastructure of a region's digital economy, which is the "cornerstone" of a region's digital economy development. The number of mobile Internet users can reflect the number of people involved in digitalization in a region, which in another way reflects the penetration of digital economy into residents' lives. The number of employed persons in urban units_information transmission, software and information technology service industry can reflect the level of digitalization of a region's industry. The digital transformation of traditional industries requires professional digital talents, while the number of people engaged in digital industries also reflects the degree of development of digital economy and digital enterprises in a region. In summary, we select these four indicators to assess the scale and level of development of regional digital economy.

3. Analysis of Empirical Results

3.1. Determination of Digital Economy Index

In determining the weights of each evaluation index, the entropy method reduces the random factors brought by the subjective assignment method and makes the amount of information among the factors more reasonable, so this paper selects the entropy method to measure the comprehensive digital economy index of the Yangtze River Delta city cluster. The specific steps are shown as follows.

In the first step, suppose there are r years, n samples and m indicators, then $X_{\theta ij}$ denotes the value of indicator j for the i-th sample in year θ.

In the second step, because the measurement units of each index value are not consistent, we first standardize them to overcome the homogeneity of each index. The specific method is as follows:

Standardization of positive indicators: $X_{\theta ij}^{'} = \frac{X_{\theta ij} - X_{\min}}{X_{\max} - X_{\min}}$.

Standardization of negative indicators : $X_{\theta ij}^{'} = \frac{X_{\max} - X_{\theta ij}}{X_{\max} - X_{\min}}$.

Where, $X_{\max}$, $X_{\min}$ denote the maximum and minimum values of the jth indicator in the i-th sample r years, i.e., the maximum and minimum values of each indicator are taken for all years.

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After the standardization of the indicators, the value range of $X_{\theta ij}^{'}$ is [0,1], which indicates the relative size of $X_{\theta ij}^{'}$ in the nth sample r years.

In the third step, since the calculation of the indicator entropy value requires a logarithmic operation, to ensure that the indicator value has some mathematical meaning, it is shifted by 0.001 units, i.e.

$$X_{\theta ij} = X_{\theta ij}^{'} + 0.001$$

In the fourth step, the information entropy is calculated.

$$Y_{\theta ij} = \frac{X_{\theta ij}^{'}}{\sum_{\theta}^{r}\sum_{i}^{n} X_{\theta ij}^{'}}$$

where $k = \frac{1}{\ln(rn)} > 0$ and satisfies $S_j \geq 0$.

In the fifth step, calculate the entropy weight of indicator j:

$$E_j = 1 - S_j$$

$$W_j = \frac{E_j}{\sum_{j}^{m} E_j}$$

In the sixth step, the composite score is calculated.

$$\mathrm{H}_{\theta i} = \sum_{j}^{m} (W_j (X_{\theta ij}^{'})^T)$$

According to the above steps, the digital economy index of "three provinces and one city" in the Yangtze River Delta from 2014 to 2019 is obtained as shown in the table.

Table 2. Digital Economy Composite Index of "Three Provinces and One City", 2014-2019

Year / Province	2014	2015	2016	2017	2018	2019
Shanghai	0.1171	0.1265	0.1105	0.1687	0.2348	0.3240
Jiangsu	0.4201	0.4581	0.4521	0.5760	0.7384	0.9156
Anhui	0.0426	0.0819	0.0910	0.1464	0.2513	0.3649
Zhejiang	0.3063	0.3461	0.3424	0.4446	0.5693	0.7454

As can be seen from the above table, the scale of the digital economy in the Yangtze River Delta region continued to increase incrementally from 2014 to 2019, with the most significant increase in the economic scale in Jiangsu Province and Zhejiang Province. In recent years,

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Jiangsu, where the traditional manufacturing industry is more developed, has vigorously promoted digital trade, driven new development by independent innovation of information technology, gradually improved the digital management of traditional manufacturing industry, and the production chain and supply chain have a new form empowered by the digital economy, effectively promoting the transformation and upgrading of industrial structure. Jiangsu is brave to grasp new opportunities and continue to promote the integration of digital economy and industrial chain, we can see from the effectiveness of the digital economy is holding up the new backbone of Jiangsu's development, GDP growth rate continues to be strong.

From the perspective of the integrated economic development of the Yangtze River Delta region, there is still a large gap between the scale of economic development of the three provinces and one city, in fact, Anhui Province is in the position of the smallest scale development of the digital economy, still a large gap compared with 0.9156 in Jiangsu Province and 0.7454 in Zhejiang Province (in 2019, for example). The scale development of digital economy can reflect the level of economic development of a region and the quality of people's living standard from the side. Anhui Province still needs to increase for the construction of new infrastructure and increase the special funding for the construction of digital economy.

Based on the above digital economy indices of each city, we use Excel to make visual maps for 2014 and 2019 (shown below) to show the spatial distribution of digital economy development scale among cities in Yangtze River Delta from another aspects.

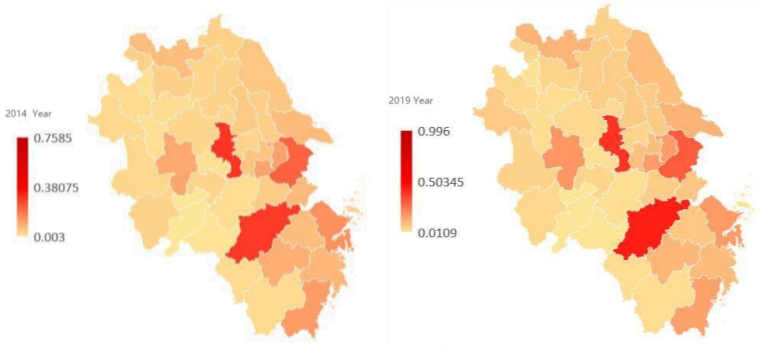

Figure 1. System overall structure

As shown in Figure 2, in 2014, the leading cities in digital economy development were Shanghai, Nanjing in Jiangsu and Hangzhou in Zhejiang, and the more developed areas were cities in southeastern Zhejiang, while the eastern part of Jiangsu and Hefei in Anhui Province were in the middle stage and most of the areas in Anhui were lagging behind in digital economy development. By 2019, the digital economy of all cities in the Yangtze River Delta urban agglomeration has expanded, with more cities developing to a medium size and fewer cities developing more slowly each year, which also reflects that the digital economy development gap in the Yangtze River Delta is gradually narrowing.

3.2. Empirical Results and Analysis based on Panel Data Regression Model

Table 3. Panel model test table

Inspection Type	Purpose of the test	Test value	Test conclusion
F-test	FE model and POOL model comparison selection	F(3,19)=109.548 p=0.000	FE Model
BP test	RE model and POOL model comparison selection	$\chi^2(1) = 28.920$ p=0.000	RE Model
Hausman test	FE model and RE model comparison selection	$\chi^2(1) = 0.724$ p=0.395	RE Model

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In this paper, a panel model is constructed using the digital economy as the explanatory variable and the value added of the secondary sector as a share of GDP as the explanatory variable . The POOL model, FE model and RE model are compared and tested separately to find the optimal regression model. From the results in Table 3 above, it is obtained that the RE model is relatively optimal under the combined F-test and chi-square test, and we finally use the RE model as the final result.

Table 4. Summary of panel type results

item	POOL Model	FE Model	RE Model
intercept distance	37.586**	null	44.882**
	-14.761	(null)	-11.392
Digital Economy	10.513	-10.934**	-10.397**
	-1.723	(-4.252)	(-3.927)
R^2	0.119	0.488	0.412
Adjustment R^2	0.079	0.38	0.385
Sample size	24	24	24
Inspection	F(1,22)=2.969,p=0.099	F(1,19)=18.082,p=0.000	$\chi^2(1)$=15.422,p=0.000

We choose the RE model as the final result, and from Table 4 above, we can see that: for the digital economy, the t-statistic is -3.927, Sig. < 0.01 i.e. significant difference at 1% level of significance, and the regression coefficient value is -10.397 < 0, indicating that the digital economy can have a significant negative relationship on the share of value added in the secondary sector in GDP.

Similarly we use the digital economy as the explanatory variable and the value added of the tertiary sector as a share of GDP as the explanatory variable for panel model construction, and the RE model as the final result.

Table 5. Summary of results of tertiary industry panel types

item	POOL Model	FE Model	RE Model
intercept distance	57.296**	null	49.382**
	-15.948	(null)	-8.347
Digital Economy	-8.874	14.109**	13.807**
	(-1.031)	-4.848	-4.736
R^2	0.046	0.553	0.505
Adjustment R^2	0.003	0.459	0.482
Sample size	24	24	24
Inspection	F(1,22)=1.062,p=0.314	F(1,19)=23.505,p=0.000	$\chi^2(1)$=22.427,p=0.000

Using the RE model as the final result, the regression coefficient value of 13.807>0 can be obtained from Table 5 above and Sig. <0.01 indicates that the digital economy will have a significant positive relationship on the value added of the tertiary sector as a share of GDP.

From the above relationship of the impact of digital economy on the value added of secondary and tertiary industries as a proportion of GDP, we conclude that in recent years under the influence of digital economy the level of traditional manufacturing and industrialization has continued to decrease, and the value added of tertiary industries, mainly service industries, has been increasing. The rapid development of big data technology has broken through the limitations of space, enabling countries to divide production globally, improving the tradability of service items, accelerating the transition of the world economy from a commodity economy

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to a service economy, and using digital technology to enhance the service economy as an important means to achieve the transformation of the global value chain. Meanwhile, due to the integration of information technology and traditional manufacturing technology, the value added of the service industry has been increasing. As can be seen from Figure 3 below, the continued development of high-tech industries in China's secondary industry will give a great impetus to the development of the tertiary industry and further promote the transformation and upgrading of the industrial structure.

3.3. Robustness Tests

In order to test the reliability of the above conclusions, we selected the four indicators of software business income, the number of cell phone subscribers, the number of Internet broadband access ports, the number of urban units of employment information transmission, software and information technology service industry to re-measure the digital economy index and do random effects analysis on the proportion of value added in the secondary industry to GDP and the proportion of value added in the tertiary industry to GDP respectively, and the results are shown below.

Table 6. Digital economy indices of three provinces and one city from 2014 to 2019

Year / Province	2014	2015	2016	2017	2018	2019
Shanghai	0.2212	0.2356	0.2474	0.3004	0.3625	0.4472
Jiangsu	0.5690	0.6415	0.7161	0.7937	0.8823	0.9281
Anhui	0.0440	0.0860	0.1059	0.1491	0.2079	0.2325
Zhejiang	0.3431	0.4470	0.4670	0.5537	0.6218	0.6915

Table 7. RE model with value added of secondary industry as a share of GDP as the explanatory variable

item	Coef	Std.Err	t	p	95% CI
intercept distance	48.242	4.592	10.506	0.000**	39.242~57.241
Digital Economy	-16.291	2.995	-5.439	0.000**	-22.161~-10.421

Table 8. RE model with the value added of tertiary sector as a share of GDP as the explanatory

item	Coef	Std.Err	t	p	95% CI
intercept distance	45.276	6.469	6.999	0.000**	32.597~57.956
Digital Economy	20.805	3.347	6.216	0.000**	14.245~27.365

Table 6, Table 7 and 8. The former regression coefficient value is -16.291<0 and the latter regression coefficient value is 20.805>0 i.e. the digital economy still has a significant negative influence on the value added of secondary industry as a share of GDP and a significant positive influence on the value added of tertiary industry as a share of GDP. In conclusion, the empirical results obtained in this paper are robust.

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4. Conclusion

4.1. AsPolicy Mechanism: Establishing a Sound Digital Trade Policy Support Mechanism to Provide Policy Guarantee for the Reshaping of Global Value Chains

At present, digital trade as the main digital economy is developing rapidly, and the supporting coordination mechanism such as laws and regulations and perfect policies should be supplemented and improved for this purpose. First of all, the government should increase the support for digital trade policies and increase special funds to promote the overall development of digital trade. The comprehensive development of digital trade will also bring China's participation in the global value chain to enhance its status. At the same time, China should urgently build up a unified domestic digital trade rules system, actively participate in the construction of the international digital trade system, and actively respond to and learn from the development of international digital trade rules and improve the supplement. Secondly, the competent government departments should focus on increasing the guidance for the digital trade industry, increasing the relevant financial investment and policy protection on the application of digital technology and digital trade to help the development of the digital economy. It should also be noted that the government should be tilted when formulating policies. Taking the Yangtze River Delta group as an example, special support funds should be set up for less developed regions to promote regional economic development and increase the development momentum of less developed regions by increasing investment and attracting talents.

4.2. Industrial Optimization: Accelerating the Construction of New Regional Infrastructure to Help the Digital Transformation of Industries and the Integrated Development of the Regional Economy

New infrastructure construction is the key to promote the digital transformation of traditional manufacturing industries and is necessary to achieve high-quality development of industrial manufacturing. The government should accelerate the new regional infrastructure to provide basic support for the development of digital economy. It should continuously improve and increase the construction of infrastructure based on big data, initially realize data concentration and sharing based on big data, and accelerate the construction of the development mode of "government helps enterprise development, technology supports industry transformation, and innovation leads future trends". Through digital economy empowerment and value chain reshaping, we will help the development of digitalization and digital industrialization of regional industries and promote high-quality development of economic integration.

4.3. Value Chain End: Improve the Allocation Mechanism of Digital Market Factors and Promote the Extension of the Value Chain of Digital Economy to the High-end

With the rapid arrival of a new round of information technology product revolution and information technology industry development changes in China, China will enter a new stage of promoting the construction of the digital economy and service industry integration of the real economy, digital national security innovation development strategy. The increasing scale of the total data demand makes it more and more important to promote the reform of the market price system of domestic data elements and to establish and improve the market rules of data elements. To accelerate the gradual realization of the marketization of information and data factor supply, and to promote the development of China's digitalized Chinese economy with high quality and long-term safe and stable development, the focus should remain on the

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priority choice of the new economic transformation and new growth mode of development by further adhering to the concept of strengthening and fully implementing the government-led innovation, coordination, green, openness and sharing interaction for development, and focusing on accelerating the construction of a scientific and innovative policy and regulatory framework. Innovation as an important fundamental basis, technological innovation and development progress as the leading new features, green technology-driven economic and social development, green transformation and innovation as the main priority goal, digital elements centralized trading system as the core, safe and convenient trusted data service model as the main support and basic legal protection of China's modern financial data elements market-based resource allocation operation and new system. To speed up the establishment of a sound or preliminary national credit data property market-based trading system construction and standardization of the entire industry price mechanism of self-regulatory incentives and constraints, to foster the establishment of a fair, efficient, standardized, honest, open and orderly third-party information asset trading market.

4.4. Internal and External Circulation: Empowering Digital Economy Development with Digital Trade, Promoting Global Value Chain Remodeling and Dual-Cycle Pattern Construction

As a point of China's economic growth pole, the Yangtze River Delta city cluster has an extremely broad domestic market and domestic demand. The relevant governments should seize the digital economy development dividend, accelerate the construction of digital trade development system, and continuously improve the sense of access and experience of residents' consumption. Focus on domestic demand, continuously increase and release domestic demand, bring more consumption and economic transactions with more convenient digital trade, and continuously promote the growth and structural adjustment of China's economy. At the same time, we should focus on the upgrading of regional industries as well as the high-end extension of the value chain, and continuously deepen reform from the supply side to meet regional, domestic and even global market demand.

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