Development Measurement of Digital Trade in the Yangtze River Delta Urban Agglomeration of China

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Abstract. Based on data from 41 prefecture-level cities in the Yangtze River Delta from 2011 to 2021, this paper constructs an evaluation index system and employs the entropy method to measure the development level of digital trade in the Yangtze River Delta urban agglomeration. It finds that, with Shanghai, Jiangsu, and Zhejiang at its core, a highly interconnected digital economic ecosystem has been formed, with enormous potential for the development of digital trade. However, issues such as infrastructure disparities and unbalanced regional development still exist. Based on these findings, the study concludes with recommendations for promoting the development of digital trade in the Yangtze River Delta urban agglomeration, providing policy references for further advancing regional economic development.

Keywords: Yangtze River Delta; Digital Trade; Urban Agglomeration; Entropy Method.

1 Introduction

The Yangtze River Delta (YRD) urban agglomeration is located in the lower reaches of the Yangtze River along the eastern coast of China. This area accounts for approximately 2.2% of China's land area and includes totally 27 cities. As one of the most economically vibrant regions in China, it contributes about one-quarter of the country's total economic output and more than one-quarter of its industrial added value, making it a vital engine of China's economy. Additionally, the YRD urban agglomeration is the largest area for China's opening up to the outside world, with a solid industrial foundation and a developed commodity economy, and it is China's largest foreign trade export base.

In the context of the vigorous development of the global digital economy, the YRD urban agglomeration plays a crucial role in digital trade. Especially after the integration of the YRD was elevated to a national strategy, this hotbed of development has created a new situation of high-quality integrated development, from industrial agglomeration to collaborative innovation, from infrastructure to public services, and the level of digital economic development in the YRD has led the nation. According to statistics, in

K. Zhang et al. (eds.), *Proceedings of the 2024 3rd International Conference on Economics, Smart Finance and Contemporary Trade (ESFCT 2024)*, Advances in Economics, Business and Management Research 305,
https://doi.org/10.2991/978-94-6463-548-5_27

2022, the combined GDP of the YRD was about 29.03 trillion Yuan, accounting for about 1/4 of the national GDP. The scale of the digital economy accounts for nearly 30% of the total national digital economy, and the scale of the integrated circuit and artificial intelligence industries accounts for about 3/5 and 1/3 of the national total, respectively.

Despite the increasing importance of the digital economy in the region, digital trade remains understudied due to the lack of a comprehensive evaluation system. The strengths and weaknesses of digital trade within the area are unclear, and relevant policies are not well-developed. Therefore, there is an urgent need to supplement and improve research in this field. Therefore, this study aims to construct a scientifically comprehensive evaluation index system for digital trade, to assess the development level of digital trade in the YRD urban agglomeration, and to provide policy references for promoting high-quality economic development in the region.

2 Literature Review

Since the beginning of the 21st centrury, scholars have engaged in extensive discussions and interpretations of the definition of digital trade. In 2010, Weber proposed that digital trade involves products or services transmitted electronically, highlighting its convenience and digital characteristics[1]. In 2013, the United States International Trade Commission (USITC) defined digital trade as international trade and domestic business activities conducted over the Internet, including digital products, services, social media, and search engines, etc.[2] The China Academy of Information and Communications Technology points out that digital trade is a form in which digital technology plays an important role in trade, and its essential characteristics are the digitalization of trade methods and trade objects[3].

Despite the increasing importance of digital trade, there currently lacks an unified measurement method, which poses certain challenges for the statistics of digital trade. Some researchers use the data on digitally delivered trade defined in the OECD-WTO-IMF “Handbook on Digital Trade” for analysis, while the majority prefer to construct a comprehensive index system. Feng and Duan(2022) found that there is a certain degree of differentiation in the development of digital trade among 49 countries, but the imbalance is narrowing[4]. The development of digital trade is influenced by the level of economic development, urbanization process, industrial structure upgrading, degree of openness to foreign trade, institutional quality, and the depth of digital trade rules(Hu et. al, 2022)[5].

While extant literature prefers evaluating the digital trade from a global or national level, in-depth studies on the internal development and regional differences within a single province are scarce. Zhou and Cui(2022) believed that the development of China’s digital trade exhibits characteristics of spatial agglomeration and unbalanced regional development, showing an overall pattern of stronger development in the east and weaker in the west, and stronger in the south than in the north[6]. Yao(2022) also found that the overall level of China’s digital trade development showed an upward trend, but there were significant disparities among different regions and provinces[7].

These studies provide reference for understanding China's digital trade, but due to lack of a unified measurement framework, there is less research on the digital trade in the YRD urban agglomeration. Therefore, this paper constructs a comprehensitve evaluation index system to evaluate the level of digital trade in the YRD region.

3 Research Methods

3.1 Selection of Indicators

With reference of the studies from Feng and Duan[4], Hu et. al[5], Zhang and Liang[8], it builds an evaluation index system to measure the development level of digital trade. It includes one primary indicator, four secondary indicators and 15 tertiary indicators from four aspects, covering internet infrastructure, digital trade capability, logistics environment, and trade potential, which are shown in Table 1.

Table 1. Comprehensive Evaluation Index System of Digital Trade Development Level.

Primary Indicator	Secondary Indicator	Tertiary Indicator	Symbol
Digital Trade Development Level	Internet Infrastructure	Number of landline telephone users at the end of the year (ten thousand)	X1
		Number of mobile phone users at the end of the year (ten thousand)	X2
		Number of internet users per hundred people	X3
		Number of mobile phone users per hundred people	X4
	Digital Trade Capability	Degree of financial development	X5
		Telecommunications business revenue (ten thousand yuan)	X6
		Proportion of employees in computer services and software industry	X7
		Number of patent authorizations	X8
	Logistics Environment	Postal service revenue (ten thousand yuan)	X9
		Highway mileage	X10
		Per capita highway freight volum	X11
	Trade Potential	Trade openness (foreign trade volume/GDP)	X12
		Per capita GDP (yuan)	X13
		Total retail sales of consumer goods in the city (ten thousand yuan)	X14
		Level of science and technology (expenditure on science and technology/financial revenue)	X15

3.2 Data Sources

The primary data sources are from the "Statistical Yearbook" of Shanghai, Zhejiang, Jiangsu, and Anhui Province from 2011 to 2021. In addition, data from the statistical

yearbooks published by the statistical bureaus of the 41 prefecture-level cities in the YRD in 2011 were also referenced.

3.3 Entropy Method

(1) The first step is data standardization. This process aims to eliminate the impact of dimensions, ensuring that all data can be compared on a unified scale. For positive indicators (i.e., the larger the indicator value, the better), this paper uses the following formula (1) for standardization. For negative indicators (i.e., the smaller the indicator value, the better), the formula (2) is used as below:

$$x_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \tag{1}$$

$$x_{ij} = \frac{max(x_j) - x_{ij}}{max(x_j) - min(x_j)} \tag{2}$$

In the formula (2), x_{ij} represents the original value of the j-th indicator, $max(x_j)\ and\ min(x_j)$represent the maximum and minimum values of that indicator, respectively.

(2) The second step is to calculate the weight of the indicators. For each indicator, calculate its weight in each sample with the formula (3). In the formula (3), p_{ij} represents the weight of the j-th indicator for the sample, where n is the total number of samples.

$$p_{ij} = \frac{x_j^{\cdot}}{\sum_{i=1}^{n} x_{ij}^{\cdot}} \tag{3}$$

(3) The third step is to calculate the entropy value of the indicators. Use the weight to calculate the entropy value of each indicator, with the formula(4). In the formular (4), e_j represents the entropy value of the j-th indicator for the sample. k is a constant, and n is the total number of samples.

$$e_j = -K\sum_{l=1}^{n} p_{ij} \ln(p_{ij}) \tag{4}$$

(4) The fourth step is to calculate the variation coefficient of the indicators. The variation coefficient is an important measure of the information utility of the indicators, and the calculation formula is as below. In the formular (5), d_j represents the variation coefficient of the j-th indicator, $e_j$is the entropy value of the indicator.

$$d_j = 1 - e_j \tag{5}$$

(5)The fifth step is to calculate the indicator weights. Determine the weight of each indicator based on the difference coefficient, with the formula (6). In the formular (6), W_j represents the weight of the j-th indicator, and m is the total number of indicators.

$$W_j = \frac{d_j}{\sum_{j=1}^{m} d_j^{\cdot}} \tag{6}$$

(6) The sixth step is to calculate the comprehensive score of the sample. Finally, using the obtained indicator weights and the standardized data, calculate the comprehensive score for each sample with the formular (7). In the formula (7), Z_i represents the comprehensive score of the i-th sample.

$$Z_i = \sum_{j=1}^{m} w_j x_{ij}^{'} \tag{7}$$

4 Resutls Analysis

Based on the data processing mentioned above, the comprehensive score of digital trade development in cities of YRD (2011 - 2021) are obtained, as shown in Table 2.

Table 2. Comprehensive Score of Digital Trade Development in cities of YRD (2011 - 2021).

City Name	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Shanghai	0.847	0.851	0.838	0.865	0.869	0.867	0.866	0.866	0.867	0.857	0.772
Hangzhou	0.156	0.164	0.142	0.213	0.205	0.222	0.223	0.220	0.222	0.235	0.268
Suzhou	0.232	0.245	0.228	0.223	0.215	0.212	0.210	0.209	0.230	0.203	0.149
Nanjing	0.142	0.146	0.139	0.146	0.141	0.144	0.145	0.145	0.149	0.149	0.137
Ningbo	0.130	0.130	0.119	0.155	0.134	0.169	0.150	0.152	0.157	0.155	0.129
Wuxi	0.107	0.106	0.116	0.141	0.130	0.133	0.125	0.118	0.126	0.121	0.096
Zhoushan	0.088	0.081	0.068	0.079	0.078	0.081	0.073	0.081	0.094	0.100	0.093
Shaoxing	0.105	0.109	0.099	0.110	0.076	0.087	0.092	0.092	0.085	0.095	0.082
Hefei	0.122	0.077	0.073	0.083	0.078	0.098	0.098	0.093	0.098	0.093	0.082
Changzhou	0.089	0.100	0.094	0.107	0.080	0.091	0.090	0.090	0.098	0.086	0.077
Taizhou	0.095	0.098	0.092	0.087	0.077	0.095	0.086	0.093	0.090	0.088	0.075
Wenzhou	0.110	0.108	0.092	0.117	0.112	0.113	0.111	0.111	0.114	0.109	0.074
Jinhua	0.099	0.107	0.100	0.112	0.093	0.112	0.108	0.115	0.117	0.110	0.074
Jiaxing	0.094	0.098	0.083	0.090	0.083	0.094	0.091	0.091	0.090	0.096	0.073
Nantong	0.091	0.093	0.085	0.091	0.105	0.096	0.093	0.097	0.094	0.085	0.068
Huzhou	0.080	0.080	0.074	0.092	0.059	0.071	0.066	0.075	0.077	0.075	0.063
Yancheng	0.068	0.076	0.064	0.078	0.058	0.057	0.064	0.064	0.064	0.064	0.058
Xuzhou	0.075	0.067	0.072	0.094	0.078	0.082	0.079	0.070	0.078	0.076	0.056
Zhenjiang	0.067	0.073	0.068	0.096	0.072	0.076	0.062	0.066	0.059	0.066	0.055
Taizhou	0.065	0.077	0.069	0.071	0.063	0.061	0.062	0.058	0.061	0.062	0.053
Quzhou	0.059	0.053	0.052	0.077	0.053	0.067	0.055	0.059	0.062	0.059	0.050
Lianyungang	0.056	0.068	0.055	0.073	0.063	0.062	0.052	0.059	0.052	0.053	0.050
Yangzhou	0.079	0.077	0.080	0.101	0.062	0.065	0.061	0.073	0.066	0.060	0.049
Lishui	0.053	0.053	0.051	0.053	0.062	0.060	0.053	0.051	0.052	0.053	0.049

Huaian	0.046	0.054	0.044	0.066	0.052	0.052	0.052	0.052	0.049	0.048	0.043
Suqian	0.049	0.052	0.061	0.076	0.055	0.053	0.043	0.042	0.050	0.052	0.042
Wuhu	0.035	0.033	0.034	0.051	0.042	0.040	0.042	0.042	0.036	0.037	0.039
Bengbu	0.029	0.032	0.029	0.047	0.037	0.044	0.037	0.036	0.037	0.038	0.038
Maanshan	0.038	0.041	0.039	0.038	0.027	0.033	0.028	0.030	0.032	0.036	0.033
Tongling	0.056	0.060	0.060	0.053	0.026	0.036	0.034	0.024	0.040	0.049	0.033
Fuyang	0.039	0.041	0.043	0.058	0.047	0.044	0.046	0.057	0.038	0.036	0.032
Xuancheng	0.027	0.034	0.033	0.035	0.030	0.027	0.027	0.030	0.024	0.028	0.029
Huainan	0.029	0.030	0.023	0.039	0.028	0.029	0.030	0.024	0.027	0.028	0.027
Lu'an	0.038	0.045	0.040	0.041	0.044	0.040	0.039	0.040	0.031	0.034	0.027
Chizhou	0.031	0.025	0.022	0.032	0.022	0.028	0.026	0.021	0.026	0.033	0.026
Chuzhou	0.026	0.030	0.031	0.046	0.042	0.051	0.035	0.048	0.036	0.036	0.026
Suzhou	0.027	0.030	0.030	0.037	0.034	0.035	0.034	0.035	0.028	0.026	0.025
Huai'an	0.023	0.017	0.019	0.037	0.035	0.032	0.032	0.032	0.021	0.023	0.025
Anqing	0.035	0.037	0.034	0.044	0.034	0.035	0.034	0.035	0.032	0.025	0.024
Bozhou	0.021	0.027	0.027	0.034	0.034	0.038	0.036	0.035	0.024	0.030	0.022
Huangshan	0.029	0.034	0.036	0.037	0.028	0.024	0.031	0.025	0.026	0.022	0.020
YRD	0.090	0.092	0.087	0.101	0.089	0.094	0.091	0.092	0.092	0.091	0.079

Note: This table is organized in descending order of 2021 scores

Table 2 shows that from 2011 to 2021, as the core city of the YRD region, Shanghai has consistently maintained a high score in digital trade indicators, with scores above 0.8, demonstrating its strong power and leading position in the field of digital trade. In 2021, the score dropped to 0.772 due to the impact of the pandemic, which may have been attributed to trade restrictions, supply chain disruptions, and other issues that affected the performance of digital trade. However, overall, Shanghai's development in digital trade is stable and mature during the studied period.

Hangzhou City in Zhejiang Province has shown an upward trend in its comprehensive scores, increasing from 0.156 in 2011 to 0.268 in 2021. This upward trend may be attributed to Hangzhou's substantial investment and forward-looking planning in the construction of digital infrastructure. By continuously improving network coverage, broadband speed, and the construction of data centers, Hangzhou has provided solid technical support for digital trade, enabling the rapid development of related industries such as e-commerce, cloud computing, and big data analysis. Secondly, as an important base for China's internet industry, Hangzhou is birthplace to a number of internet companies with international influence, such as Alibaba Group. The innovation capabilities and business expansion of these companies have not only driven the growth of local digital trade, but also secured Hangzhou's position in the global digital trade landscape.

Nanjing's digital trade comprehensibe scores show a relatively stable trend, maintaining around the level of 0.14 over the long term. This stability reflects Nanjing's steady development and effective management in the field of digital trade, and also indicates the city's mature strategy in adapting to digital transformation and promoting

trade innovation. Ningbo's scores are also relatively stable and have risen after 2015, which may be related to the digital transformation of Ningbo Port and trade facilitation measures. Other cities, such as Wuxi, Zhoushan, and Shaoxing, although having relatively lower scores, also show varying degrees of growth trends. This indicates that these cities are actively developing and exploring in the field of digital trade.

From 2011 to 2021, while Zhejiang Province has the highest level of digital trade development, Anhui Province has been in the bottom for a long time, which is related to its relatively weak economic foundation. According to the ranking of digital trade development level in 2021, the top three cities in the YRD region are Shanghai, Hangzhou, and Suzhou, which have shown significant advantages in digital trade. In contrast, the cities at the bottom of the ranking are all located in Anhui Province. At the same time, except for the provincial capital city of Hefei, all the prefecture-level cities in Anhui Province are at the very end, which shows that there is a certain gap between Anhui Province and other regions in the YRD in the overall development of digital trade.

5 Discussion and Conclusion

5.1 Discussion

As an essential engine of China's economy, the scale of digital trade in the YRD urban agglomeration has been increasing year by year. By measuring the development level of digital trade in this area, this study provides decision-making support and reference for further promoting regional economic development. However, in the process of the growth of digital trade, the development of the YRD region is uneven. This imbalance is mainly manifested in the first-tier cities in the region, such as Shanghai, Hangzhou, Suzhou and Nanjing, which have developed rapidly due to their strong economic foundation, perfect infrastructure and abundant human resources, ranking in the forefront of digital trade development, and scoring high in the development of digital trade. In contrast, some second- and third-tier cities and more remote areas are lagging behind in the development of digital trade due to problems such as insufficient infrastructure, brain drain and capital shortage, such as some prefecture-level cities in Anhui Province, and the bottom three cities belong to Anhui Province.

Therefore, in order to promote the comprehensive development of digital trade in the YRD region, it is necessary to strengthen infrastructure construction and promote inter-regional coordination and cooperation. Such cooperation can cover multiple levels such as policy coordination, resource sharing, and technical exchanges, so as to jointly create an open, inclusive, mutually beneficial and win-win environment for the development of digital trade. In addition, regional cooperation should also include jointly formulating long-term digital trade development plans, promoting trade facilitation within the region, and strengthening collective bargaining power in the international arena, so as to enhance the competitiveness and influence of the entire YRD region in global digital trade.

5.2 Conclusion

This paper constructs a comprehensive evaluation index system for the development of digital trade, and uses the entropy method and statistical panel data to measure the development level of digital trade in the YRD urban agglomeration, which has important theoretical and practical significance. Although this study provides strong support for promoting the high-quality development of regional economy, there are still some limitations in the research. For example, it is difficult to obtain indicators and data for new forms of digital trade, and future research can add more indicators to the comprehensive evaluation indicators, and apply data sharing platforms to adapt to the diversification and dynamic changes of digital trade.

Acknowledgement

This research was funded by the Hefei University Talent Research Fund Project (20RC55), the project of Innovative Development of Social Sciences in Anhui Province (2021CX042), and the Outstanding Young Scientist Research Project of Colleges and Universities in Anhui Province (2024AH030076).

Reference

1. Weber R H. Digital Trade in WTO-Law-Taking Stock and Looking Ahead[J]. SSRN Electronic Journal, 2010,5(1):1-24.
2. United States International Trade Commission. Digital Trade in the U.S. and Global Economies, Part1[J].USITC Publication.2013(1):332-531.
3. China Academy of Information and Communications Technology. White Paper on the Development of China's Digital Trade(2020).[EB/0L]2021-04.
4. Feng, Zongxian; Duan, Dingyun. Analysis of Digital Trade Development Index and Its Influencing Factors: Based on Panel Data of 49 Countries. Journal of Beijing University of Technology (Social Science Edition), 2022(7): 100-117.
5. Hu Y, Zhou HQ, Yan B, Zou Z and Li Y (2022) An Assessment of China's Digital Trade Development and Influencing Factors. Front. Psychol. 13:837885. doi: 10. 3389/ fpsyg. 2022.837885
6. Zhou Juanmei, Cui Fenfang. A Study on the Spatiotemporal Evolution Characteristics of China's Digital Trade Development [J]. Research on Financial Development, 2022(11): 58-68.
7. Yao Na. A Study on the Measurement of the Development Level of China's Digital Trade and Research on Innovation Development Strategies [J]. Research on Science and Technology Economy and Management, 2022(11): 56-61.
8. Zhang Weihua, Liang Yunwen. The Provincial Regional Differences and Spatial Effects of China's Digital Trade Development Level [J]. Guizhou Social Sciences, 2020(12): 129-138.