An Analysis on Measurement of the Development Level of Digital Economy and Influencing Factors of the Tertiary Industry in Eastern China

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Abstract. This paper uses the entropy method to construct an evaluation system and evaluate the development level of the digital economy in Eastern China from three aspects: digital industrialization, industrial digitization, and digital innovation. It also constructs a fixed-effect model to analyze the effects of the development of digital economy on the development level of the tertiary industry from data collected from 10 provinces in Eastern China. The research found that from 2011 to 2020, the development level of digital economy in Eastern China has continuously improved. Guangdong Province, with its advantages in the Internet industry, ranks first place in evaluation. The score of digital economy development level, the proportion of science and technology expenditure in GDP, per capita GDP, and the added value of the financial industry have a positive impact on the development of the Tertiary Industry in eastern China.

Keywords: digital economy · panel data · evaluation index system · regression analysis

1 Introduction

At present, our country is at an important time for transition of high-quality economic development. The digital economy has become an indispensable part of it. Therefore, how to improve the development level of the digital economy has become a hot spot in current research. However, the economic situation in current world is still complicated. Compared with other countries, there is still room for our country's development of digital economy and there are still many problems that would impede it.

Many scholars have expressed different opinions about measurement methods. Huang Qunhui [1] maintains that the development of the digital economy can not only improve the productivity of traditional industries by promoting technological innovation, but also an important way to promote the integrated development of manufacturing and service industries. Tong Jiadong [2] concluded that the existing measurement methods from professional organizations can be roughly divided into three types, index compilation method, added value calculation method and satellite account construction method;

Y. Jiang et al. (Eds.): ICFIED 2023, AEBMR 237, pp. 283–293, 2023.
https://doi.org/10.2991/978-94-6463-142-5_32

Wei Lili [3] constructed an evaluation index system from the perspectives of digital industrialization, industrial digitization, digital governance and data value, and digital economy industry classification; Cai Shaohong [4] believes that digital economy has certain new characteristics. Therefore, he selects from four aspects: digital foundation, digital application, digital innovation, and digital environment to construct an evaluation index system for digital economic development.

2 Measurement of Development Level of Digital Economy

2.1 Construction of Evaluation Index System

Based on the definition of the digital economy represented by the China Academy of Information and Communications Technology in 2022, this paper constructs a specific evaluation index system from three different aspects: Digital industrialization, Industrial digitization and Digital innovation [5].

2.2 Data Acquisition and Processing

The data used in this paper are mainly collected from the 2011-2021 "China Statistical Yearbook", "China Education Statistical Yearbook", "China Urban Statistical Yearbook", and the statistical yearbooks of each province in eastern China. Before processing the entropy method, indicators must be standardized with following method [6], shown as (1)–(7) and the results has been shown in Table 1.

$$Standard_{ijt} = \frac{X_{ijt} - \min\{X_{jt}\}}{\max\{X_{ijt}\} - \min\{X_{ijt}\}} \tag{1}$$

t is time, i is region, j is index:

$$w_{ijt} = \frac{Standard_{ijt}}{\sum_{i=1}^{n}\sum_{t=1}^{m} Standard_{ijt}} \tag{2}$$

Calculation of ej and dj:

$$e_j = -k\sum_{i=1}^{n}\sum_{t=1}^{m}(w_{ijt} * lnw_{ijt}) \tag{3}$$

$$k = -\frac{1}{lnm} \tag{4}$$

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

m is the amounty of years and n is the amont of regions

Calculation of Wj

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

Finally Score:

$$Score = Standard_{ijt} * W_j * 100 \tag{7}$$

Table 1. Index System

First grade index	Second grade index	Third grade index	Weight
Digital industrialization	Scale of Telecom industry	Mobile phone penetration	0.0654
	Scale of Software industry	Software business revenue accounted for the proportion of gross regional product	0.0592
	Scale of Internet industry	Number of broadband Internet access ports	0.0608
		Length of long distance optical cable line	0.0572
		Number of Internet domain names	0.0561
Digitization of industry	Digitization of agriculture	Added value of agriculture, forestry, pastoral and fishery	0.0568
	Digitization of industry engineering	Value added of the secondary industry	0.0610
	The tertiary industry is digitized [7]	Proportion of enterprises with e-commerce transactions	0.0652
		The number of websites owned by the enterprise	0.0609
		Value added of the tertiary industry	0.0626
		E-commerce sales accounted for the proportion of gross regional product	0.0569
		Delivery quantity	0.0459
		Digital Financial Index	0.0664
Digital innovation	innovation input	R&D personnel investment intensity	0.0619
		Spending on education and science and technology The proportion of total financial expenditure	0.0665
	innovation output	Technology market turnover accounts for GDP	0.0407
		Number of authorized invention patent applications	0.0565

Table credit: Original

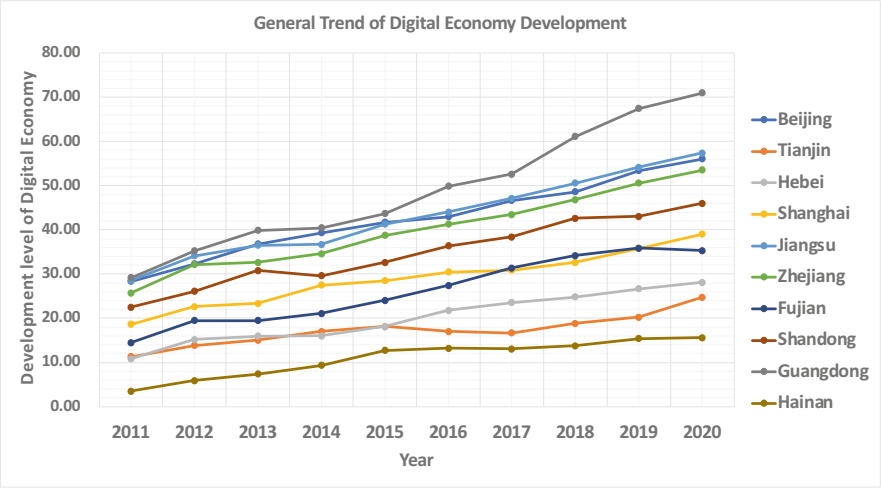

Fig. 1. General trend of digital economy. Photo credit: Original

2.3 Analysis on the Development Level of Digital Economy on Eastern China

The General trend of digital economy development has been shown in Fig. 1. From a vertical perspective, from 2011 to 2020, the development level of the digital economy in each province has been improved in different degrees. The greatest increase is in Guangdong Province, which increased from 29.18 points in 2011 to 70.95 points in 2020. Hainan Province has the smallest increase, 12.15 points, which shows that although the development of digital economy in Hainan Province has improved, the speed of it is still relatively slow. From a horizontal perspective, the overall economic development pattern in the eastern region is different. The most obvious development difference is reflected in Guangdong Province and Hainan Province. The overall developing level of Guangdong Province is relatively high, and the average score and growth rate are both ranked at first place in Eastern China, with 49.09 points and 41.77 points respectively. In contrast, the developing level in Hainan Province has always been at the bottom. In addition, the development of Beijing and Jiangsu Province has been at a relatively high level in the past decade and the speed is stable. From analysis that we have above, we could know that there is a big difference in the development level of the digital economy among the provinces in Eastern China, it also reflects that there are also corresponding problems during the development in our country.

The digital industrialization and industrial digitalization development level of all provinces in eastern China have been improved from 2011 to 2020. The results have been shown in Fig. 2 and Fig. 3. However, due to the impact of the pandemic, the digital industrialization development of each province has a downward trend in 2019 and 2020. The development of digital industrialization and industrial digitalization in Guangdong Province and Beijing are at the forefront. However, since 2015, the development level of digital industrialization in Guangdong Province has been significantly higher than Beijing which makes it score first place. This is mainly because of the rapid development rate of the software industry and the Internet industry in Guangdong Province.

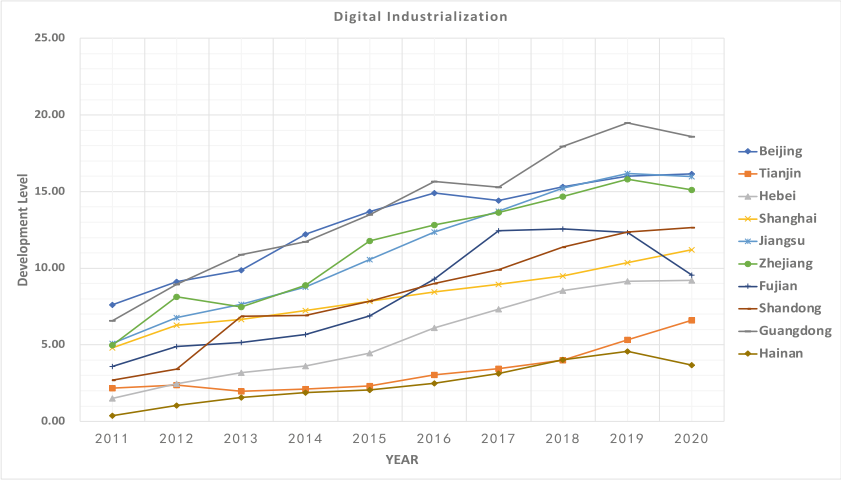

Fig. 2. Digital Industrialization. Photo credit: Original

From the data that have been analyzed above, we could know that the development scale of the Internet industry in Guangdong Province is significantly larger than that of other provinces and the proportion of its software industry revenue to GDP is also significantly higher than that of other provinces. In addition, Internet companies in Guangdong Province maintain high sensitivity and high acceptance of new technologies, new formats, and new markets. Their applications cover all aspects of people's clothing, food, housing, transportation, leisure, and entertainment, and are deeply integrated with all walks of life. This could be the main reason why the development level of the digital economy in Guangdong Province is at the forefront of Eastern China.

The result of the development level of digital innovation has been shown in Fig. 4. For this part, from the perspective of the overall development trend, the development of digital innovation in all provinces has shown a significant fall from 2014 and this is mainly caused by the changes in the proportion of education and science and technology expenditures in total fiscal expenditures. But in 2016 it began to increase again. Guangdong Province has the most Significant improvement. The main reason for that is the proportion of education and technology expenditure in Guangdong Province in total fiscal expenditure and the number of invention patent applications and authorizations have been significantly higher than in other provinces. By contrast, the overall digital innovation development level of Hainan Province has always been at the bottom of the eastern region. Although there has been a gradual upward trend since 2018, there is still a distance from other provinces.

2.4 Measurement of Development Level of Tertiary industry

By referring to the relevant literature, this paper constructs the evaluation system from following three aspects: development environment, development status and development potential [8]. Through the preliminary calculation of the obtained weights, the scores on

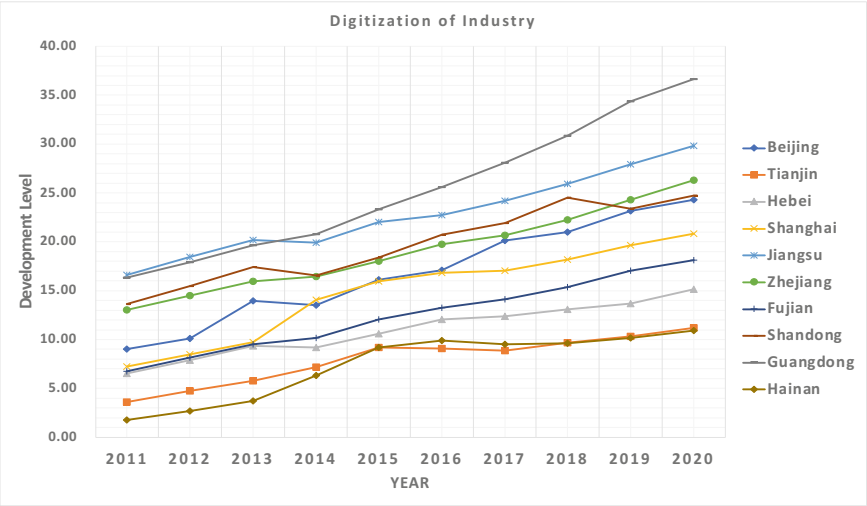

Fig. 3. Digitization of Industry. Photo credit: Original

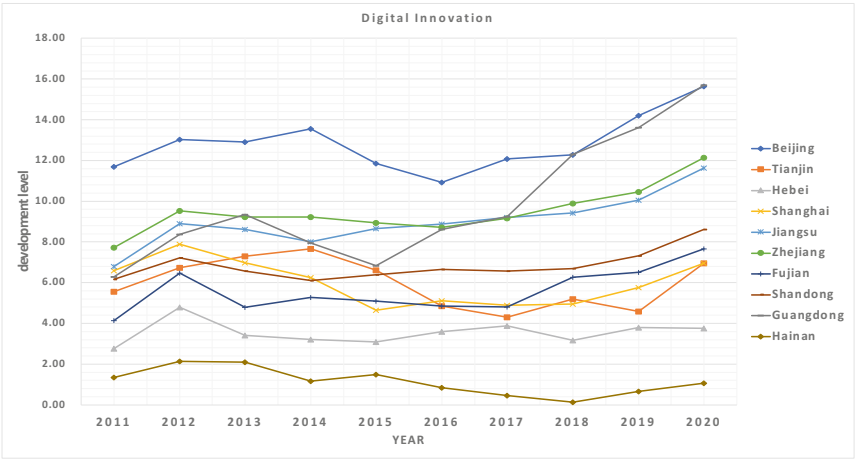

Fig. 4. Digital Innovation. Photo credit: Original

the development of the service industry are obtained and they are provided for the panel data regression in the following sections. Results are shown in Table 2.

3 Analysis of the Impact of Digital Economy Development on the Tertiary Industry in Eastern China

3.1 Variable Selection

The dependent Variable that we selected is 2011–2020 Service Industry Development Index of Provinces in Eastern China. The independent Variable are included:

Table 2. Result of weight

Index name	Variables	Weight
Development Environment [9]	Consumer Price Index	0.1746
	Value added of the financial industry	0.1698
Development Scale [10]	Investment in fixed assets of the tertiary industry	0.1695
	Average tertiary industry added value	0.1664
Development Potential [11]	Authorized patent applications	0.1533
	R&D spending	0.1665

Table credit: Original

Table 3. Result of descriptive statistical analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
consumer_index	100	636.62	124.968	436.7	910.9
score_digital	100	31.30	14.3058	3.476336	70.94968
tec_gdp	100	0.0338	0.01628	0.080786	0.067568
avg_gdp	100	81412.93	32384.71	28356.92	164927.4
finance	100	3239.48	2224.097	105.24	9906.99
score	100	30.98746	15.44473	5.546733	75.15967

Table credit: Original

Digital economy development level score (score_digital), Consumer price index (consumer_index), Ratio of science and technology expenditure to GDP (tec_gdp), per capita GDP (avg_gdp), Added value of the financial industry (finance). [11]

First, the descriptive statistical analysis of the variables is shown in Table 3.

3.2 Estimation and Testing of the Model

In the regression process, the variable score_digital is taken logarithmically and represented by the variable ln_score_digital to reduce the interference of multicollinearity. The results of correlation test between variables are shown in Table 4.

The result shows that the correlation coefficients between most explanatory variables are less than 0.8, only the correlation between finance and "ln_score_digital" is slightly higher than 0.8. At the same time, the VIF test is also performed, and the result is 2.97. The results of both tests that we have done above show that there is no serious multicollinearity between variables, in this case the reliability of the final results could be guaranteed.

Because of the existence of "pseudo-regression" phenomenon, even if there is a high R^2, it still cannot truly reflect the explanatory degree of the explanatory variables to

Table 4. Result of correlation test

	ln_score_digital	cosume_index	Finance	avg_gdp	tec_gdp
ln_score_digital	1.000				
consumer_index	−0.070	1.000			
finance	0.842***	0.074	1.000		
avg_gdp	0.518***	0.430***	0.589***	1.000	
tec_gdp	0.628***	0.258***	0.703***	0.713***	1.000

Table credit: Original

Table 5. Result of unit root test

Variable	Z-t-title-bar	P-value	Conclusion
tec_gdp	−1.4058	0.0799	Not steady
D_tec_gdp	−3.2426	0.0006	Steady
ln_score_digital	−1.4177	0.0781	Not steady
D_ln_score_digital	−3.3199	0.0005	Steady
avg_gdp	0.5625	0.7131	Not steady
D_avg_gdp	−3.8732	0.0001	Steady
consumer_index	0.3535	0.6382	Not steady
D_consumer_index	−2.7379	0.0031	Steady
Finance	1.3655	0.9139	Not steady
D_finance	−2.6983	0.0035	Steady

Table credit: Original

Table 6. Result of cointegration test

Method	Statistic	P-value
Westerlund	2.9691	0.0015
Pedroni	5.3252	0.0000

Table credit: Original

the explained variables and the regression results obtained at this time are unreliable. Therefore, in order to avoid the bias, IPS test will be selected for the unit root test. Table 5 shows the result of the unit root test.

The results show that each variable has a unit root, so a cointegration test should also be performed. The cointegration test in this paper selects Westerlund test and Pedroni test. The result has been shown in Table 6.

Table 7. Result of FEM

Variable	Coef.	Std. Err	P>|t|
ln_score_digital	6.11067	1.5757	0.000
consumer_index	0.00831	0.1376	0.547
finance	0.00551	0.0003	0.000
avg_gdp	0.00005	0.00003	0.024
tec_gdp	133.1206	44.1545	0.003
Observations	100		
R-squared	0.931		

Table credit: Original

By analyzing the test results, we could conclude that: the null hypothesis could be rejected when the significance level is 0.01, also indicating that there is a co-integration relationship between the explanatory variables and the regression residuals obtained are stable. Therefore, the obtained results from the regression are reliable.

The result of F test indicates that P=0.0000, which means the null hypothesis could be rejected at the level of precision of 0.01and the Hausman test could be continued. The result shows that P=0.0009, so the null hypothesis is seriously rejected at the level of precision of 0.01. In this case, we could conclude that the model is a FEM. (Fixed Effect Model). Results are shown in Table 7.

From Table 7, R^2 (within) is 0.931, indicating that the explanatory variable can explain 93.1% of the explained variable, so the model fitting effect is good.

4 Conclusion

From the analysis that we have above, we could conclude that the variables of the digital economy development level score, the proportion of science and technology expenditure to GDP, per capita GDP, and the added value of the financial industry all passed the significance test at the significance level of 0.05, indicating that these factors have a positive impact on the development of the tertiary industry; while, consumer price index did not pass the exam, which means the impact of it on the development of the tertiary industry is not significant. The coefficient of digital economy development is 6.11067, indicating that while other variables remain unchanged, every 1% increase in the level of digital economy development will lead to an average increase of 0.0611 points in the province's service industry development index.

5 Suggestion

Based on the research and analysis that we have above, we get the following suggestions which could further improve the developing level of economy in various regions of our country.

First, during the developing process, the government should build and continuously improve the local digital economic development system, establish a sound digital economic system, and actively encourage enterprises to increase capital investment in core information technology research and development.

Second, improve the construction of a digital talent team, strengthen technological innovation and accumulate high-quality talent resources with complex backgrounds and professional skills. [12] The demand for high-quality talent is increasing the developing level. All regions should speed up the establishment of educational resource-sharing platforms and establish a high-level digital talent team.

Third, pay more attention to the regional differences during the development of digital economy and try hard to promote regional connectivity. For areas with relatively high developing level, regional advantages can be fully utilized to drive the economic development of surrounding cities.

References

1. Hu Shihua, Huang Tianjian, Wang Kai. Collaborative Development of Digital Economy and Green Economy: Spatial-temporal differentiation, Dynamic Evolution and Convergence Characteristics [J]. Modern finance and economics (journal of tianjin university of finance and economics), and 2022 (9): 3–19. https://doi.org/10.19559/j.carolcarrollnki.12-1387.2022.09.001.
2. Tong Jiadong, Zhang Qian. The connotation of digital economy and its extraordinary contribution to future economic development [J]. Journal of Nankai (Philosophy and Social Sciences Edition),2022(03):19–33.
3. Wei Lili, Hou Yuqi. Digital economy research on the development of China's urban green [J]. Journal of quantitative technical economics, 2022, 33 (08) 6:60–79. https://doi.org/10.13653/j.carolcarrollnkijqte.2022.08.005.
4. CAI Shaohong, Gu Cheng, Zhang Zaijie. Spatial and temporal characteristics and influencing factors of digital economy at provincial level in China [J]. East China Economic Management,202,36(07): 1–9. https://doi.org/10.19629/j.cnki.34-1014/F.211219002.
5. Influence on the development of the digital economy to the agricultural high quality [J]. Journal of hebei agricultural university (social science edition), 2022, 24 (01): 18 to 27. https://doi.org/10.13320/j.carolcarrollnkijauhe.2022.0003.
6. Wang Juanjuan, She Qianjun. Digital measure and regional economic development level more in China [J]. Circulation economy in China, 2021, 35 (08): 3–17. https://doi.org/10.14089/j.carolcarrollnkicn11-3664/f2021.08.001.
7. Jiao Shuaitao, Sun Qiubi. Measure and its influencing factors of the digital economy development in China [J]. Journal of research in the world, 2021 (7): 13–23, https://doi.org/10.13778/j.carolcarrollnki.11-3705/c.2021.07.002.
8. Yao Huixiang. Research on the impact of digital economy on China's service industry [J]. Business Information,2022(10):159–162.
9. Xiao Lei, Wu Juanjuan. The regional difference of the development of China's service industry and spatial spillover effect [J]. Journal of statistics and decision, 2020, 4 (16): 91–95. https://doi.org/10.13546/j.carolcarrollnkitjyjc.2020.16.020.
10. Wu Chuanqing, Deng Mingliang. Measurement and Influencing factors of Integrated development level of Manufacturing and service industry in the Yangtze River Economic Belt [J]. Journal of yangzhou university (humanities and social science edition), 2020, 24 (4): 44–62 https://doi.org/10.19411/j.carolcarrollnki.1007-7030.2020.04.004.

11. LIU Jun, Yang Yunyun, ZHANG Sanfeng. The digital economy measure of China and the driving factors [J]. Journal of Shanghai economic research, 2020 (6): 81–96. https://doi.org/10.19626/j.carolcarrollnkicn31-1163/f 2020.06.008.
12. Wang Bin-yan, Tian Jun-feng, Cheng Li-sha, Hao Fei-Long, Han Han, Wang Shi-Jun. Digital economy space differentiation and influencing factors of China [J]. Journal of geographical science, 2018, 38 (6): 859–868. https://doi.org/10.13249/j.carolcarrollnki.SGS.2018.06.004.