Measurement and Analysis of Digital Economy Development Index -- Take Shandong Province as an Example

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ABSTRACT

This paper takes Shandong Province as an example to measure and analyze the digital economic development index, which is important to research the digital economic development index of agricultural development cities. Firstly, three development dimensions of quality, scale, and efficiency suitable for the development characteristics of Shandong province are selected, and the evaluation system of the digital economy development index is constructed by using the relevant data of Shandong province from 2010 to 2020. The entropy method is used to fit the digital economy development index and analyze the digital economy development index level. Secondly, the Moran index is used for spatial autocorrelation analysis to investigate the influence of geographical location on the level of digital economic development index. Finally, the obstacle degree model is introduced into the influencing factors analysis of the digital economy development index, which makes an innovative exploration for the research method of the digital economy development index. The research results show that: in terms of time, the results of entropy method show that the digital economy development index shows an increasing trend, but since 2016, the digital economy development index has fluctuated up and down under the influence of technological development and industrial layout. In space, the Moran index shows that the digital economy development index is in the state of agglomeration distribution and finds that the digital economy development index has the possibility of an "agglomeration effect." Based on this, the paper proposes to draw the policy inspiration of improving the level of digital economy development index from the national and Shandong perspectives and promote the three-core leadership based on the characteristics and advantages of Jinan, Qingdao, and Yantai in the digital economy and smart city. We should fully play our unique geographical advantages and promote coordination, linkage, openness, and cooperation.

Keywords: *Digital economy development index; Entropy value method; Moran index; Obstacle model*

1. INTRODUCTION

As a new strategy of national informatization development in the new era, building digital China is of great significance to adapt to the new historical orientation of China's development, fully implement the new development concept, and cultivate new kinetic energy with informatization. As an essential way to promote high-quality regional development, we should promote the deep integration of the Internet, big data, artificial intelligence, and the real economy with the support of digital infrastructure, data resource system and network security, the core of digital industrialization and industrial digitization, and the digital application of government governance and services for the benefit of the people[1]. It is a concrete manifestation of comprehensively improving the core competitiveness of the development in the era of the digital economy[2]. Therefore, taking Shandong Province as an example to analyze the digital economy development index will help to accelerate the transformation of industrial digitization in the whole Province and create a new situation of building a strong digital province[3].

First of all, the index system is constructed, and the entropy method is used to fit the digital economic development index, and the statistical data of Shandong Province are used to analyze the level of the digital economic development index. Secondly, spatial autocorrelation analysis is carried out to investigate the

spatial heterogeneity of the digital economic development index level. Finally, an obstacle model is established to deeply analyze the key factors that affect the regional digital economic development index.

2. THEORETICAL ANALYSIS FRAMEWORK AND RESEARCH METHODS

Taking the development of digital economy informatization as the core theory, this paper analyzes the relationship between economic and social systems using economic growth theory. It is constructed the theoretical analysis framework of the "quality scale efficiency" digital economy development index[4] and uses the entropy method to fit the four dimensions of quality, scale, and efficiency. Moran index is used to test the spatial autocorrelation of the digital economy development index of cities in Shandong Province. The obstacle model further verifies the key factors of spatial autocorrelation results by the key factors [5].

2.1. Theoretical analysis framework

Based on the research results of the digital economy development index in the existing literature, this paper constructs the theoretical mechanism framework of the digital economy development index. The digital economy development index integrates four dimensions: economic[6], social, technological development, and industrial layout. In economic growth theory, from the affirmation of classical economic growth theory and highlighting the importance of labor and capital to the neoclassical growth theory focusing on technology, knowledge, and human capital, and the new development direction composed of new ideas such as industrial structure optimization, scientific and technological innovation, and economic globalization is becoming five an essential part of neoclassical economic theory.

2.2. Research method

Firstly, the entropy method, a standard method for weighting comprehensive evaluation indicators, is selected to fit the digital economy development index to analyze the change law of the index with time. This method can weigh each index more objectively and avoid the deviation caused by human factors. Secondly, in the research of spatial effect, the global spatial autocorrelation is used to measure the spatial form of the level of digital economic development index. This method is an important method to measure the spatial correlation between geographical elements and geographical things, and the Moran index is the most commonly used test method of spatial autocorrelation. Finally, using the obstacle degree model can refine the main influencing factors affecting the comprehensive index based on evaluating the comprehensive level, which is conducive to putting forward more targeted improvement measures to improve the comprehensive index of digital economic development index.

2.3. Data standardization of digital economic development index

Assuming that there are y years, n observation objects, and M evaluation indicators, then X λ Ij is the second λ The j-th evaluation index of the i-th observation object. In order to eliminate the influence of different dimensions on the evaluation results, this paper standardizes the evaluation indexes. Standardized treatment of positive and negative indicators.

2.4. Measurement model of digital economy development index

Based on the digital economic development index theory, three dimensions are designed: "quality scale efficiency." The standardized data are used for index fitting by the entropy method. Give equal weight to the four dimensions to obtain the digital economic development index (NEDI),

$$NEDI=1/4B1+1/4B2+1/4B3+1/4B4 \quad (1)$$

NEDI represents the digital economic development index, and B1, B2, B3, and B4 represent the four dimensions of economic, social, technological development, and industrial layout.

2.5. Spatial pattern model of digital economy development index in Province

In order to analyze the spatial connection and correlation of the digital economic development index, this paper adopts the global spatial autocorrelation Moran index, which is generally between [-1,1], and the calculation formula is shown in formula (2).

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i-1}^{n}(x_i - x)\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}} \quad (2)$$

n is the number of research objects; Is the observed value. I is between -1 and 1, I>0 indicates a positive spatial correlation, spatial entities are in aggregate distribution, I<0 indicates a negative spatial correlation, spatial entities are in discrete distribution, and I = 0 indicates spatial entities are in random distribution; The greater the absolute value of I, the greater the correlation of spatial distribution.

2.6. Obstacle model

Moran index is used to solve the spatial distribution problem of digital economic development index, but the main influencing factors of digital economic

development index level in different geographical locations are different. Therefore, it is necessary to analyze further why geographical location affects the digital economic development index. The obstacle degree model can analyze the obstacle degree of different influencing factors on the explained variables. Therefore, the obstacle degree model is selected to analyze the obstacle factors of each prefecture-level city index. The obstacle degree is calculated by index contribution degree, index deviation degree, and obstacle degree.

[1] Index contribution w refers to the contribution of a single indicator to the overall goal.

[2] Index deviation degree (Oij) refers to the gap between a single index and the development goal of the system.

$$O_{ij}=1-x_{ij} \quad (3)$$

[3] Barrier degree (ij) refers to the impact of a single index on the development index of the digital economy

$$I_j = O_{ij}w_j / \sum_{j=1}^{n} O_{ij}w_j \quad (4)$$

3. DATA SOURCES AND DESCRIPTIVE STATISTICS OF VARIABLES

3.1. Data sources

This paper selects the spatial panel data of the digital economy development index from 2010 to 2020, which comes from the statistical yearbook of Shandong Province from 2011 to 2021. In the practical application of data, in order to eliminate the impact of different dimensions on the evaluation results, this paper first standardized the original data of each evaluation index and then made mathematical analysis

3.2. Variable selection

According to the above theoretical analysis, combined with economic growth theory and industrial cluster theory, the index system is established following the principles of replicable development, low cost, availability, and comparability.

According to the index system involved in the current literature on digital economic development index, the principle of compiling digital economic development index, the theoretical mechanism of digital economic development index and the development situation of Shandong Province, the evaluation index system of digital Shandong development index are constructed, as shown in Table 1.

Table 1. Evaluation index system of digital economy development index

Target layer	Criterion layer	Index layer	Company	Tendency
Digital economy development index (NEDI)	Development quality of digital economy	IC output	100 million	+
		Internet penetration	%	+
		Long-distance optical cable line density	Kg / 10,000 cubic meters	+
		Mobile phone base station density	Ten thousand pieces/cubic meter	+
		Internet broadband access port ratio	%	+
		The proportion of telephone users	%	+
		The proportion of e-commerce sales in GDP	%	+
	Development scale of the digital economy	Software business income	Ten thousand yuan	+
		Sales revenue of electronic information industry	Ten thousand yuan	+
		Number of digital information enterprises	Ten thousand	+
		Expenditure on new product development in the digital economy industry	Ten thousand yuan	+
		Total telecom services	Ten thousand yuan	+
		The proportion of Internet broadband users	%	+
	Development efficiency of the digital economy	Enterprise e-commerce sales	Ten thousand yuan	+
		The proportion of employment in the information service industry	%	+
		R%D investment intensity	%	+

	Number of R & D institutions in the digital economy industry	万个	+
	Internal expenditure of R%D funds for digital economy industry	Ten thousand yuan	+
	Number of patent applications in the digital economy industry	个	+

4. EMPIRICAL RESULTS AND ANALYSIS

4.1. Analysis of digital economy development index

Firstly, after the standardization of the original data, the entropy method is used to fit the three dimensions of the digital economic development index; Secondly, the development index of the digital economy is calculated; Thirdly, the calculated digital economic development index is normalized by 0-1; Finally, the digital economy development index from 2010 to 2020 is obtained, as shown in Table 2.

Table.2 digital economy development index 2010-2020

Year	B1(quality)	B2(efficiency)	B3 (scale)	NEDI (Digital economy development index)	Standardized NEDI
2010	6769.84	37.44	335246.44	87011.88	0.38
2011	7979.72	31.30	346716.19	90377.39	0.43
2012	9458.54	39.37	383569.79	100074.79	0.55
2013	10596.18	40.53	459302.53	119659.89	0.80
2014	11774.23	40.83	499617.57	130151.76	0.94
2015	12508.79	40.60	513007.70	133718.71	0.98
2016	12783.94	40.81	414343.24	9081.61	0.67
2017	11078.56	40.85	214033.67	58211.95	0.02
2018	11830.62	40.89	270508.80	72710.96	0.20
2019	12731.41	47.19	263548.00	71217.73	0.18
2020	12963.29	47.90	231925.65	63365.23	0.08

The results show that the digital economy development index fluctuated continuously from 2015 to 2019 under technological development and industrial layout. The development speed from large to small is quality (B1), scale (B2), and efficiency (B3).

4.2. Spatial autocorrelation analysis of digital economy development index

In order to investigate the influence of geographical location on the level of digital economy development index, a global Moran test is required, and the results are shown in the table. The results show that the I value in 2010 is less than 0, there is negative spatial autocorrelation. The I values in 2011-2020 are greater than 0, so there is positive spatial autocorrelation, indicating that the positive impact of the digital economy development index in space since 2011 is stronger than the negative impact. In addition, the Z values from 2011 to 2020 are greater than 1.5% 65, and the p-value is less than 0.05 except 2016 05. The Z value is significant, indicating that the digital economic development index distribution in the whole Province presents a concentrated distribution.

Table.3 2010-2020 digital economy development index

Year	I	Z	P	Result
2010	-0.040	0.149	0.882	Dispersed distribution
2011	0.324	3.038	0.002	Agglomeration distribution
2012	0.229	2.415	0.015	Agglomeration distribution
2013	0.640	5.192	0.000	Agglomeration distribution
2014	0.395	3.436	0.001	Agglomeration distribution
2015	0.501	4.003	0.002	Agglomeration distribution
2016	0.196	1.761	0.078	Agglomeration distribution
2017	0.649	5.294	0.000	Agglomeration distribution
2018	0.517	3.977	0.000	Agglomeration distribution
2019	0.454	3.793	0.0001	Agglomeration distribution
2020	0.222	2.043	0.041	Agglomeration distribution

5. CONCLUSION

Based on the analysis of the theory and literature of digital economic development index, and according to the empirical analysis of statistical data in Shandong Province, this paper sums up the main conclusions of this paper. It then carries on the relevant discussion combined with the existing research and actual situation. Finally, the corresponding policy implications are put forward for the whole country and Shandong Province, respectively. Based on the statistical data of Shandong Province, this study uses the entropy method to measure the level of digital economic development index from three dimensions: quality, scale, and efficiency, and then uses spatial autocorrelation and obstacle degree model. This paper studies the effect of each dimension of the digital economic development index. The results show that the development index of the digital economy shows an increasing trend, but it has fluctuated continuously under the influence of resource allocation and environmental protection since 2015. Therefore, the preliminary judgment of resources and environment is the key factor restricting the development index of the digital economy.

The development index of the digital economy has global spatial autocorrelation. Since 2010, the digital economic development index has shown a state of spatial agglomeration distribution, indicating that the digital economic development index has externalities. The development direction of the digital economic development index of the neighboring areas is the same. It is supposed that a particular area's digital economic development index is high. In that case, it will produce positive externalities so that the level of digital economic development index in neighboring areas shows an upward trend, forming a state of spatial agglomeration. On the contrary, it will produce negative externalities and restrain the development level of the digital economy in neighboring areas.

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