Research on Entropy-Weighting TOPSIS Method Based on Shanghai Digital Economy Index System

Juanjuan Qi[1st], Wei Li [2nd*], Xiaofang Li[3rd], Ling Yuan [4th]

[1]School of Management, Suzhou University, Suzhou, Anhui, China
[2]School of Management, Suzhou University, Suzhou, Anhui, China
[3]School of Management, Suzhou University, Suzhou, Anhui, China
[4]School of Mathematics and Statistics, Suzhou University, Suzhou, Anhui, China

[1]e-mail: q2165675082@163.com
[2]e-mail: wli04306@163.com
[3]e-mail: lixiaofang864@163.com
[4]e-mail: yl3302666256@163.com

Abstract. As the new engine of high-quality economic development in China and even the world, digital economy has become the core driving force of economic growth in recent years. This is not only the key area of the new round of industrial reform, but also a major issue related to the long-term stability of the country. Therefore, the status of digital economy in national economies of various countries is constantly improving, and the goal of building a digital power is also put on the agenda of our country. Among them, from the perspective of national digital economy development, Shanghai's digital economy development is particularly prominent. Throughout the country, Shanghai is far ahead in the development of digital industry, big data and e-commerce economy. Therefore, the research object of this paper takes Shanghai as the representative and focuses on the development of digital economy in Shanghai, trying to analyze the present situation and benefits of digital economy development in Shanghai, and put forward corresponding conclusions and suggestions according to the data analysis. Digital economy is a new driving force to promote the transformation and upgrading of manufacturing industry. Exploring the influence mechanism of digital economy on manufacturing service will help to promote the high-quality development of manufacturing industry.

Keywords: Digital:economy; Entropy method ;TOPSIS method ;Relative pros and cons.

1 Introduction

The development of digital economy mainly has three basic conditions: digital economy infrastructure, information industry and the external environment for digital economy development. The economic development of Shanghai has the above three basic conditions. Compared with other cities in China, it is more representative in research and can better predict the general trend of the development of digital economy

H. Wu et al. (Eds.): CSIEDE 2022, ACSR 103, pp. 656–662, 2022.
https://doi.org/10.2991/978-94-6463-108-1_73

in other cities in China. How to construct and measure the digital economy is an important proposition for the pursuit of high-quality economic development in the new era, and it is particularly important for the sustainable and healthy development of the Chinese economy [1]. Since there are many disputes in the classification of the domestic digital economy industry, what is the impact of the digital economy on social activities in terms of its essence? From what perspective should we study the digital economy? The measurement of the added value of the digital economy, etc. The indicators selected in this paper are clearly defined and recorded with exact figures, which makes the research results more authentic and convincing.

How to improve the theoretical system of the digital economy in the context of China to guide the practice of high-quality economic development will become an important issue for future theoretical and empirical research on the digital economy [2]. Practice yields true knowledge, and the deep-seated content behind practice is the real source of its development. As far as the digital economy is concerned, there are many problems such as imperfect theory, some doubts, evaluation criteria, etc., which ultimately need to be empirical and qualitative. comprehensively to solve.

The Fourth Plenary Session of the 19th Central Committee of the Communist Party of China identified "data" as a factor of production for the first time, and the digital economy with data as the core factor of production and digital technology as the core driving force will become a new driving force for economic growth [3]. This clear definition is more conducive to practical development, and also points out a new journey for economists to study. The physical carrier of data value empowerment—modern information network amplifies the value-added and fusion value-added effects of data itself, and improves the performance of data value empowerment and digital technology empowerment [4]. Data is no longer a digital code that looks ordinary, as if it has no actual value, and the level of economic benefits behind it has increasingly become one of the important indicators to measure in daily life.

Based on the status quo and development potential of the digital economy, following the principles of advancement, feasibility and scientificity [5], combined with the relevant data of the Shanghai Municipal Bureau of Statistics of the digital economy in the past ten years, entropy analysis and TOPSIS analysis were carried out on Shanghai data. The use of evaluation methods is not static. It is a good method to choose an appropriate method that can effectively and clearly reflect the data. It is worth noting that the advantage of the entropy weight method is that it is objective. In order to consider the characteristics of the data itself and the actual economic significance, a combination of objective and subjective weighting is used to determine the weight of each indicator. The scientific nature of the evaluation system is directly related to the understanding of the pros and cons of the object being evaluated, and it is of great significance to apply scientific methods to the construction of the evaluation system [6].

2 Data analysis

2.1 Calculation of entropy weight

1) Selection of indicators and data.

This research selects the Internet penetration rate in Shanghai from 2011 to 2020, employees in urban units in digital economy-related industries, employees in urban units, permanent resident population at the end of the year, total telecommunications business, mobile phone penetration rate, and digital financial inclusion in Peking University. The seven indicators of the index fit the comprehensive development of the digital economy from three aspects: industry development, employment status, and ecological construction.

2) Weight calculation.

In this study, the entropy method was used to calculate the weights. Entropy is a measure of uncertainty. The greater the amount of information, the smaller the uncertainty and the smaller the entropy; the smaller the amount of information, the greater the uncertainty and the greater the entropy. Since the indicators selected this time are all positive indicators, there is no need to perform positive processing on them, and the information entropy e value is calculated. The formula is as follows:

$$E_j = -K\sum_{i=1}^{m} P_{ij}\ln(P_{ij}) \tag{1}$$

The information utility d value is the information entropy redundancy, which measures the repetition degree of information. The calculation formula is as follows:

$$D_j = 1 - E_j \tag{2}$$

Based on the information entropy e value and the information utility d value, the weight calculation formula is:

$$W_j = d_j / \sum_{j=1}^{n} d_j \tag{3}$$

Therefore, the data weight of each indicator can be calculated through the above formula. After the data weight of each indicator is calculated, we can try to carry out the next step of analysis.

3) Calculation result of entropy value.

After the data is operated on, the results are summarized in the following table:

Table 1. Summary of the results of weight calculation by entropy method

index	Information entropy value e	Information utility value d	Weight coefficient w
Internet penetration	0.9993	0.0007	0.35%

Employed persons in urban units related to the digital economy	0.9545	0.0455	23.37%
Employed persons in urban units related to the digital economy	0.9982	0.0018	0.91%
Year-end resident population	0.9999	0.0001	0.03%
Total telecom business	0.8916	0.1084	55.64%
Mobile phone penetration	0.9968	0.0032	1.65%
Peking University Digital Financial Inclusion Index	0.9648	0.0352	18.06%

Among them, the employment of urban units in digital economy-related industries, the total amount of telecommunications business, and the digital financial inclusion index of Peking University are important indicators, which have a large weight. Internet penetration rate, employed persons in urban units, permanent resident population at the end of the year, and mobile phone penetration rate are secondary indicators with smaller weights.

2.2 Analysis of relative merits and demerits

The TOPSIS method ranks the evaluation objects according to the distances between the evaluation objects and the positive and negative ideal solutions, so as to evaluate the relative merits and demerits.

First of all, it is necessary to determine the evaluation indicators to ensure that the evaluation indicators are all positive. The indicators selected in the index system established in this research are all positive indicators.

Secondly. In the above table, D+ and D- respectively represent the distance between the evaluation object and positive and negative ideal solutions. The calculation formula is as follows:

$$D = \sqrt{\sum_{j=1}^{m} W_j (A_j - data_{ij})^2} \tag{4}$$

Finally, C value represents the proximity between the evaluation object and the optimal solution. The larger the value, the closer it is to the optimal solution. Its calculation formula is as follows:

$$C = D^- / (D^+ + D^-) \tag{5}$$

The positive and negative ideal solutions and relative proximity of each evaluation object can be obtained by calculation, which are summarized in the following table:

Table 2. TOPSIS evaluation calculation results

year	Positive ideal solution distance D+	Negative ideal solution distance D-	Relative proximity C	Sort results
2011	1.338	0	0	10
2012	1.314	0.049	0.036	9
2013	1.241	0.161	0.115	8
2014	1.203	0.201	0.143	7
2015	1.104	0.275	0.2	5
2016	1.243	0.214	0.147	6
2017	1.14	0.296	0.206	4
2018	0.742	0.623	0.456	3
2019	0.311	1.035	0.769	2
2020	0.001	1.338	0.999	1

Calculate the positive ideal distance and the negative ideal distance with the year as the research object. The maximum value of the positive ideal distance is 1.338 in 2011, the minimum value is 0.001 in 2020, the maximum value of the negative ideal distance is 1.338 in 2020, and the minimum value is 0 in 2011.

Draw a line chart based on the data in the table as follows:

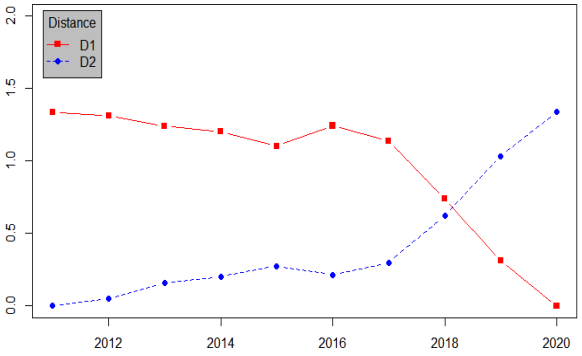

Fig. 1. Line chart of related pros and cons

First of all, it can be seen from the figure that the overall relative pros and cons have gradually improved over time, and the intersection of the positive ideal distance and the negative ideal distance roughly occurred in 2013. Secondly, it can be found that the development of Shanghai's digital economy has the characteristics of early start and rapid development, and the overall development of the overall industry is coordinated.

In the end, we came to the conclusion that the development level of Shanghai's digital economy is relatively high and the development status is relatively stable.

3 Conclusion

With the emergence of research institutions, the prosperous economic phenomenon of Shanghai's digital economy has also been studied and explored by various research institutions, and it can be used as a reference for other regions across the country, which will promote the development of digital economy in other regions. Through the data collection of various regions in China and the deep analysis of the data presented by Shanghai, we can draw the following conclusions. First of all, from the data analysis of Shanghai, it can be seen that the telecom business volume dominates and is the biggest direct beneficiary. Through the continuous expansion and development of telecom business in various industries, Shanghai promotes the steady development of digital economy with the transaction volume of telecom business. On this basis, with various e-commerce transactions as the main driving force and digital currency as the center, the two-way cooperation has promoted the rapid development of Shanghai's digital economy. Therefore, the business volume of Shanghai Telecom is the main influencing factor of Shanghai digital economy. Secondly, from the comparative advantages and disadvantages of the overall data presentation, in 2013, Shanghai's digital economy situation improved and made a qualitative leap after that, and it was concluded that Shanghai's digital economy started earlier. The digital economy has higher forward-looking and timely standards for its products and services, which requires not only a complete theoretical knowledge system but also timely development. The Shanghai Municipal Government is the leader of China's digital economy development, and has not fully understood the concept and theory of digital economy in other parts of the country. Shanghai is at the forefront of digital economy development with a sense of cutting-edge opportunity, and Shanghai has a sense of opportunity for the future development of digital economy. Finally, from the data charts since 2013, it can be seen that the development of digital economy in Shanghai is relatively balanced. With a balanced and stable mentality, Shanghai has innovated on the original traditional theoretical system and achieved a breakthrough in the development of digital economy. Stable digital infrastructure construction is also an important part of Shanghai's digital economy.

Acknowledgment

This paper is funded by the following projects:

Research project on innovation and development of Social Sciences in Anhui Province (2021CX189);

Research project on innovation and development of Social Sciences in Anhui Province (2020CX204);

Key project of Humanities and Social Sciences in Colleges and universities of Anhui Province (SK2019A0539);

Suzhou College National Innovation and Entrepreneurship Training Program (202210379033);

Suzhou College Provincial Innovation and Entrepreneurship Training Program (S202110379129);

Suzhou College School-level innovation and entrepreneurship training program (ZCXM22-064);

References

1. Wang Jun, Zhu Jie, Luo Qian: "Measurement of the Development Level and Evolution of China's Digital Economy", "Research on Quantitative Economy and Technology Economics" [J], 2021 No. 7 DOI: 10.13653/j.cnki.jqte.2021.07.002
2. Chen Xiaohong, Li Yangyang, Song Lijie, Wang Yangjie: "The Theoretical System and Research Prospects of Digital Economy", "Management World" [J] DOI:10.19744/j.cnki.11-1235/f.2022.002020
3. Ge Heping, Wu Fuxiang: "Digital Economy Empowers High-Quality Economic Development: Theoretical Mechanism and Empirical Evidence", "Nanjing Social Sciences" [J] DOI:10.15937/j.cnki,issn1001－8263.2021.01.003
4. Wang Jiayuan: "Digital Economy Empowers the Deep Integration and Development of Industries: Action Mechanism, Problems, Challenges and Policy Suggestions", "Macroeconomic Research" [J]DOI:10.16304/j.cnki.11-3952/f.2022.05.011
5. Ma Yinxu, Wan Tingting: "Analysis of the Impact of Digital Economy on Employment in Hebei Province and Countermeasures - Based on Entropy Method and SNA Technology", "Strategic Operation" [J]DOI:10.19885/j.cnki.hbqy.2022.02.015
6. Liu Ziqi, Guo Binghui, Cheng Zhen, Yang Xiaobo, Yin Ziqiao: "Science and Technology Strategy Evaluation Based on Entropy Fuzzy Analytic Hierarchy Process", "Computer Science" [J]DOI:10.11896/jsjkx.1907007