Research on the Development Level of Digital Economy Based on Fuzzy Comprehensive Evaluation

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Abstract. A reasonable review of the development stages of the digital economy is of great significance to the coordinated development of the digital economy. This research establishes an evaluation index system for the development level of digital economy in Anhui Province, calculates the index weight by the entropy method, and uses the fuzzy comprehensive evaluation method to comprehensively evaluate the development of its digital economy. The results show that the digital economy in Anhui Province has a considerable Industry and user base, the development of digital economy in Anhui Province is still in its infancy and needs to be developed urgently. And based on the results of the analysis, specific recommendations are put forward.

Keywords: Development level of digital economy · index system · entropy method · fuzzy comprehensive evaluation

1 Introduction

With the emergence of the digital features of the global economy and the gradual integration and development of informatization, digitization, and all walks of life in society, the digital economy has obviously become a new engine that promotes high-quality development of the Chinese economy [1]. As an emerging economic form, research on the evaluation of digital economy development at home and abroad is gradually developing.

In the early days, the research scope and field of the digital economy showed a bipolar distribution, and the research scope was large, mainly focusing on domestic and international. Shi Jiaying (2018) summarized and evaluated the progress of digital economic cooperation under the APEC framework, and looked forward to the prospects of digital economic cooperation [2]. Nela Miloševiæ (2018) assessed and ranked 28 EU countries based on their data performance and made recommendations for their progress in the field [3]. For the digital economy integration industry, Guo Qinghua (2018) analyzed the relevant issues that should be paid attention to in the evaluation process of English classroom teaching based on the digital environment, and on this basis constructed the evaluation index of English classroom teaching [4].

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In the later period, the scope of research gradually narrowed, and research on the development of digital economy in various provinces and regions emerged one after another. The research field is no longer limited to a single industry, and research on various industries and the overall national economy is also emerging. MR Efimova (2021) assesses the technological readiness of each region's digital economy by constructing a comprehensive indicator and predicts the main obstacles to developing "digital economy" projects in the region and the whole country [5]. Zhang Yuanyuan (2021) used the entropy method to calculate the digital economy development score, and put forward suggestions on the development of the digital economy in the Yangtze River Delta and Beijing-Tianjin-Hebei regions [6]. Zhai Wenjing (2022) also used the entropy method to analyze the degree of difference in the development of sample cities in Zhejiang Province, and came to the conclusion that the development level of the digital economy in Zhejiang Province has gradually improved [7]. Chen Kaixuan (2022) used a variety of models and entropy method to analyze the factors affecting the development of the digital economy, and came to the conclusion that the development of science and technology and the protection of intellectual property rights have a greater impact on the digital economy. The development of the digital economy [8]. The research on the evaluation of the development status of the digital economy at home and abroad mainly shows the trend of gradually narrowing the research scope and expanding the research field, but the research scope is still concentrated in the areas with relatively developed economy, and there are still less research in the areas with relatively lack of economic development.

This research adopts the fuzzy comprehensive evaluation method of entropy value to evaluate the development level of digital economy in Anhui Province more objectively and comprehensively. First, a large number of literatures are consulted, and the current research situation in the field of digital economy is deeply analyzed, and the evaluation index of digital economy in Anhui Province is established accordingly. Secondly, according to the relevant data collected from the Anhui Provincial Statistical Yearbook and processed, finally, the weight of each index is calculated by the entropy weight method and a fuzzy comprehensive evaluation analysis model is constructed to put forward practical suggestions for the development of the digital economy in Anhui Province.

2 Fuzzy Comprehensive Evaluation of Digital Economy Development in Anhui Province

2.1 Indicator System Determination and Weight Calculation

This study builds an index system based on the index proposed by Zhang Meiling (2022) [9]. This study uses the fuzzy comprehensive evaluation method to evaluate the development of digital economy in Anhui Province, and builds an evaluation index system based on three levels of industrial scale, industrial base and user scale. The selected index system is shown in Table 1.

In this study, the entropy method is used to calculate the weight of each index. As an objective weighting method, the entropy method can avoid the deviation between

Table 1. Fuzzy Comprehensive Evaluation Index System

Indicator system	
Industrial scale	Total telecom business
	Industrial fixed asset investment
Industrial base	Number of patents granted in China
	Optical cable line length
	Industry employees
User scale	Number of broadband access users
	Number of mobile phone users

the final evaluation and the fact due to subjective weighting to a certain extent. At the same time, in order to standardize the writing of subsequent papers, the index system is numbered, from "total telecommunication services" to "number of mobile phone users", which are sequentially numbered as $x_1, x_2 \ldots x_7$.

First of all, the index data selected in this study is subjected to dimensionless processing, and the processing formula is:

$$Z_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{1}$$

Then calculate the information entropy value of each index data, the calculation formula is:

$$E_j = -\frac{1}{lnn} \sum_{i=1}^{N} p_{ij} lnp_{ij} \tag{2}$$

In the formula, p_{ij} is calculated as $p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}}$, and in the presence of $p_{ij} = 0$, exists $\lim_{pij \to 0} p_{ij} lnp_{ij} = 0$.

From this, the calculation formula of the index weight of the entropy weight method is obtained as:

$$W_j = \frac{1 - E_j}{m - \sum E_j} \quad (0 \le j \le m) \tag{3}$$

Finally, the weight calculation results are calculated according to the entropy method, which are arranged as shown in Table 2.

To sum up, the set of indicator weights in this study is:

$$W = \{0.06, 0.07, 0.06, 0.12, 0.46, 0.09, 0.14\}$$

2.2 Fuzzy Comprehensive Evaluation

The fuzzy comprehensive evaluation index system determined in this study is shown in Table 1. Therefore, the evaluation factor set in the fuzzy comprehensive evaluation is:

$$U = \{x_1, x_2, x_3, x_4, x_5, x_6, x_7\}$$

Table 2. Summary of weight calculation results by entropy method

Index	Weights
Total telecom business	0.06
Industrial fixed asset investment	0.07
Number of patents granted in China	0.06
Optical cable line length	0.12
Industry employees	0.46
Number of broadband access users	0.09
Number of mobile phone users	0.14

At the same time, according to the overall data of this research, four fuzzy evaluation grades are divided, and the specific division interval is shown in Table 3.

It can be seen from Table 3 that the set of comments in this study is:

$$V = \{Level1, Level2, Level3, Level4\}$$

In the previous part of the article, the entropy method has been used to calculate the index weights of this research, and the weight set is:

$$W = \{0.06, 0.07, 0.06, 0.12, 0.46, 0.09, 0.14\}$$

On the one hand, the factor set, comment set and weight set of this study have been given. On the other hand, the membership function of this fuzzy comprehensive evaluation is a trapezoidal distribution membership function, which is combined with the evaluation level to divide the interval. The specific form of the function is:

$$r_{i1} = \begin{cases} 1, & x \le 0.25 \\ \frac{0.5-x}{0.25}, & 0.25 < x < 0.5 \\ 0, & x \ge 0.5 \end{cases} \tag{4}$$

$$r_{i2} = \begin{cases} 0, & x \le 0.25 \\ \frac{x-0.25}{0.25}, & 0.25 < x \le 0.5 \\ \frac{0.75-x}{0.25} & 0.5 < x \le 0.75 \\ 0, & x \ge 0.75 \end{cases} \tag{5}$$

Table 3. Digital economy development level range

Development level	Numerical interval
Level 1	[0–0.25)
Level 2	[0.25–0.5)
Level 3	[0.5–0.75)
Level 4	[0.75–0.95]

$$r_{i3} = \begin{cases} 0 & x \leq 0.5 \\ \frac{x-0.5}{0.25}, & 0.5 < x \leq 0.75 \\ \frac{0.75-x}{0.2}, & 0.75 < x \leq 0.95 \\ 0, & x \geq 0.95 \end{cases} \tag{6}$$

$$r_{i4} = \begin{cases} 0, & x \leq 0.75 \\ \frac{x-0.75}{0.2}, & 0.75 < x < 0.95 \\ 1, & x \geq 0.95 \end{cases} \tag{7}$$

Based on the above formula, the fuzzy judgment matrix of this research is calculated as follows:

$$R = \begin{bmatrix} 0 & 0.16 & 0.84 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0.2 & 0.8 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0.84 & 0.16 & 0 & 0 \end{bmatrix}$$

In this study, the selected form of fuzzy comprehensive evaluation operator is: $M(min, max)$, The result set calculation formula is:

$$B = W \cdot R \tag{8}$$

After calculation, the result set of this fuzzy comprehensive evaluation is as follows:

$$B = \{0.46, 0.14, 0.06, 0\}$$

From this, it can be judged that the development of digital economy in Anhui Province is at the level of 1.

2.3 Chapter Summary

Through the overall fuzzy comprehensive evaluation process of the digital economy development level in Anhui Province, the following two conclusions can be drawn:

1) From an objective point of view, the industrial base represented by "the number of industrial employees" occupies the largest weight in the evaluation index system of the digital economy development level in Anhui Province, and the weight coefficient is 45.62%. The industrial base expanded rapidly.
2) Based on the fuzzy comprehensive evaluation results, it can be seen that the development level of the digital economy in Anhui Province is in the initial stage, which is consistent with the weight calculation results of the entropy method.

3 Conclusions

The analysis draws the following conclusions: First, Anhui's digital economy has a considerable industry and user base. Second, the development of the digital economy in Anhui Province is in its infancy and has broad prospects for development.

Based on these two findings, this paper makes the following recommendations. First of all, the government should vigorously develop the digital economy carrier. The carrier of the digital economy is the cornerstone of the development of the digital industry and the integration of industrial digitalization. Only a strong digital economy carrier can promote the rapid development of the digital industry, thereby expanding the breadth and depth of the digital economy and industry, and exerting its effectiveness. Secondly, based on the actual situation of Anhui Province, actively expand investment in traditional infrastructure and new digital infrastructure, especially new digital infrastructure, and give full play to the regional basic advantages. In addition, enterprises should seize digital opportunities and make full use of data resources. The development of the modern economy is inseparable from the support of data, which requires data to predict returns and control risks.

Enterprises should continue to innovate data processing platforms, make full use of their own resources, provide data support for other industries, and at the same time grasp the needs of the masses and strive to expand the market. Promoting the development of digital industrialization, boosting the process of industrial digitalization, realizing the deep integration of digital economy and industry, improving the efficiency of digital economy in high-quality economic development, and improving the scale and quality of its own digital industry are key measures.

This study evaluates the development level of the digital economy in Anhui Province, and gives specific suggestions based on its current development status. It provides direction and guidance for the development of the regional digital economy, regulates the development of the digital economy market, and avoids the development of the digital economy from entering a misunderstanding. The next step of research should provide a more scientific evaluation index system and adopt a more reasonable evaluation method for the higher level of regional digital economy development level.

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