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Indicator System Construction and Evaluation Analysis of Data Factor Marketization

Shaoheng Luo *, Yingjie Huang

Management Institute, Sichuan University of Science and Engineering, Yibin 644000, China
* **Corresponding author**: Shaoheng Luo (Email: 15281400517@163.com)

Abstract: The construction of data factor market is an important cornerstone for the implementation of the development strategy of digital China and digital economy. At present, China's data factor market is in the early stage of development, with rich data resource reserves but high imbalance in market development, it is of great theoretical and practical significance to clearly understand the state of data factor market development. According to the basic connotation of data factor marketization, this paper constructs the index system of data factor marketization, and measures the development level of 31 provinces in China from 2011 to 2023 by using the entropy weight TOPSIS method, and further analyzes the temporal and spatial evolution characteristics of data factor marketization with the help of the method of intrinsic microstate. The results of the study objectively reflect the overall situation, core drivers, problems and regional characteristics of the current development of China's data factor market, and provide a basis for the subsequent formulation of data factor market policies and the promotion of the integration of the national data factor market.

Keywords: Data factor marketization; Entropy weight TOPSIS; Intrinsic microstate.

1. Introduction

With the deep integration of information technologies such as artificial intelligence, blockchain, cloud computing, and big data with the real world, it has given rise to the massive output and circulation of data. Driven by the combined effect of data empowerment and digital innovation, the commercial value of data elements has become increasingly prominent, and has become a key element driving economic and social development [1]. Although data has long been regarded as an important economic resource for production and exchange [2], the early understanding of data was more at the level of raw unprocessed data [3]. As research continues, academics are beginning to recognize that data needs to be aggregated, processed, and organized to become data elements in the true sense of the word [4].

Driven by the combined effect of data empowerment and digital innovation, the commercial value of data elements has become more and more prominent, and has become a key factor driving economic and social development [1]. However, the simple possession of data resources will not bring about economic effects, and data elements can only play a greater value in circulation and trade [5]; if enterprises and even the whole industry realize the circulation and trade of data elements, and promote the process of data element marketization, it will certainly bring about great economic effects [6]. How to promote the circulation of data elements in the transaction has become a hot topic of general concern in the academic community, the academic community on the basic system of data transactions [7], data property rights system [8], pricing strategies [9] and other aspects of the extensive discussion, these studies for the circulation of data elements in the transaction provides a practical path to accelerate the process of data elements marketization.

Since the Fourth Plenary Session of the 19th CPC Central Committee included data as a production factor for the first time, China has gradually established the idea of promoting the circulation and development of data factors by market-oriented means [7]. Although the shape and construction direction of the data factor market have been clearly defined, on the whole China's data factor market is in the early stage of development, with abundant data resource reserves but a high degree of imbalance in the development of the market [10]. According to statistics, China's data volume will grow at an average annual rate of 30% between 2018 and 2025, but there are huge differences between regions based on the "digital divide", exacerbating the segmentation of the data factor market [11].

As data factors are widely emphasized as a new type of production factors, it is increasingly important to measure and evaluate the development status of data factor markets. At present, there are two main methods to measure the level of data factor marketization: first, the comprehensive index evaluation method. Some scholars construct the index system of data factor marketization from the connotation of data factor marketization. For example, Tao et al. measure the marketization level of data factors from three dimensions: dependence, non-exclusivity and permeability [13]. Second, important events in the construction of data factor market are adopted as the measurement of data factor market development. For example, Ting Chen [14] uses whether a city has established a digital exchange as a measure of the development level of data factor market; Fang J C [12] focuses on the launching of a city's public data open platform.

At present, the theory and practice of the development of data factor marketization has a basic knowledge, but there are still two deficiencies: first, the knowledge of the development level of data factor marketization is mainly based on the combing and empirical judgment of the development stage of data factor market [12], which lacks the assessment and comparison based on objective data; second, the main argumentation basis of the existing imbalance in the development of data factor marketization is mainly based on the assessment of the development level of "digital" between the eastern and western regions. Secondly, the main argumentation for the uneven development of the data factor market is mainly based on the understanding of the "digital divide" between the eastern and western regions [11], which lacks the analysis of systematic thinking and the test of objective data. The current empirical and rough understanding of the data factor market theory is not conducive to accurately grasp the actual development stage of the market and the subtle problems, which limits the formulation of policies to differentiate the needs of different regions and cities, and to a large extent restricts the seizing of the first opportunity for high-quality development.

Based on the above analysis, this paper constructs the evaluation index system of data factor marketization at the provincial level from the basic connotation of data factor marketization and related documents, measures the development level of data factor marketization in 31 provinces in China from 2011 to 2023 using entropy weight TOPSIS method; treats the 31 provinces as a complex system, introduces the method of intrinsic microstate, and analyzes the contribution rate of intrinsic microstate to explore the development level of data factor marketization in China. The method of intrinsic microstates is introduced to analyze the contribution rate of intrinsic microstates to explore the main development mode; analyze the historical evolution process of intrinsic microstates to explore the main influencing factors; and recognize the actual situation of the development of data factor marketization through the mapping of microstates. Through the basic analysis of the method of intrinsic microstates, more targeted policies can be formulated for different regions to promote the development of data factor marketization to a higher level, as well as to improve the policy basis for the construction of market integration in the field of data factors in different provinces.

The rest of the paper is structured as follows: part 2 is the construction of the indicator system and level measurement analysis of data factor marketization; part 3 is the construction of the intrinsic microstate and spatio-temporal analysis of data factor marketization; and part 4 is the discussion and policy recommendations.

2. Indicator System Construction and Level Measurement of Data Factor Marketization

2.1. Construction of Data Factor Marketization Indicators

Data factor marketization is a dynamic and complex process, covering multiple aspects such as production, distribution, circulation as well as trading, etc. It is difficult to find a single indicator to measure the real level of data factor marketization development, and it is necessary to comprehensively consider multiple indicators and various factors. Based on the research of Hu Wei [15] and Yan Meng [16], this study constructs the indicator system of this paper in accordance with the basic connotation of data elements defined in the previous article and the realistic background of the Opinions of the CPC Central Committee and the State Council on Building a Data-Based System and Better Utilizing the Role of Data Elements.

In the construction of specific indicators, this paper mainly focuses on the four dimensions of market foundation, market environment, market scale and market potential. Market foundation mainly includes the talent foundation and networking foundation, combined with Chen Xiaohui's related research, mainly includes four, one is the proportion of information software employees, the second is the Internet broadband access rate, the third is the length of long-distance fiber optic cable lines, and the fourth is the number of domain names. The market environment mainly refers to Fan Gang's measurement of China's marketization level, setting three secondary indicators of the degree of development of factor markets, the degree of development of product markets, and the relationship between the government and the market. In addition to this, this paper combines the research on data governance as well as government regulation [17] and other aspects of the data factor market planning into the market environment. Specifically, by organizing the documents related to big data, data governance and digital economy, and adopting the crawler technology to extract the corresponding keywords to get the specific situation of data factor market regulation. The market size mainly refers to the studies of Li Yingjie et al. and Guo Jinhua [18] et al. The total amount of telecommunication business is used as a proxy variable for digital industrialization, and the ratio of e-commerce sales to the value added of the tertiary industry in each region is used as a proxy variable for industrial digitization. In addition, considering that data trading is an important part of data factor marketization, the scale of data trading also affects the overall level of data factor marketization, based on this, this paper uses the number of big data trading platforms as a proxy variable for the scale of data trading. Market potential mainly contains two aspects of technology factor marketization and financial factor marketization. This paper mainly refers to the research of Hu Wei [15], and uses the R&D investment in scientific and technological innovation of industrial enterprises above large-scale RD funding as a proxy variable for the marketization of technological factors, and uses the digital HP financial index as a proxy variable for the marketization of financial factors.

In summary, this paper selects a total of 13 indicators from the four dimensions to construct the indicator system of data factor marketization level, and the specific definitions and testing methods are shown in the following table. Among them, the first column is the variable that this paper focuses on; the second column is the first-level indicators, which cover the four basic aspects of data factor marketization, and the third column is the second-level indicators, which belong to the further classification of the first-level indicators, and refine the characteristics of the data factors, and the specific indexes or calculation methods are shown in the third column.

Table1. Indicator System

Target level	Tier 1 Indicators	Second-level indicators	Specific measurement method
Level of marketization of data elements	Market base	Talent base	Information Software Employees
		Internet broadband access rate	Internet broadband access rate
		Length of long-distance fiber optic cable lines	Long distance fiber optic cable line length
		Number of domain names	Direct Data
	Market Environment	Factor Market Development	Degree of factor market development
		Data Factor Market Planning	Data Economy Policy Related Documents
		Product Market Development	
		Government-Market Relationship	Government-Market Relationship
	Market Size	Digital Industrialization	Total Telecom Business
		Industrial Digitization	E-commerce sales
		Scale of data transactions	Number of data transaction platforms
	Market Potential	Marketization of Technology Factors	RD funding for science and technology innovation R&D investment by industrial enterprises above designated size
		Financial Factor Marketization	Digital inclusive finance index

The data sample scope of this paper is the provincial data from 2011 to 2023, and the sources are mainly China Statistical Yearbook, National Bureau of Statistics, Fan Gang China Marketization Index, Peking University Fabulous website, and Peking University Financial Digital Center, and part of the data, such as the number of data trading platforms, are manually sorted out by the author.

2.2. Measurement Methods of Data Factor Marketization

This paper adopts the entropy weight TOPSIS method to measure data factor marketization. The entropy weight method determines the weight by measuring the information entropy of each evaluation index. The information entropy reflects the degree of data disorder, the greater the data fluctuation, the smaller the information entropy, indicating that the indicator contains more information, and the higher the weight. the TOPSIS method measures the relative advantages and disadvantages of each evaluation object by calculating its distance from the ideal solution and the negative ideal solution. Combining the entropy weight method with the TOPSIS method can overcome the subjective nature of TOPSIS evaluation and objectively evaluate the development level of China's data factor marketization. The calculation steps are as follows:

Normalized data by extreme value method

In the multi-indicator evaluation system, each evaluation indicator usually has a different scale, in order to eliminate the influence of the scale on the evaluation indicators of the development of data factor marketization, the data are first standardized:

Forward indicator: $Y_{ij}=\frac{x_{ij}-x_{i\,min}}{x_{i\,max}-x_{i\,min}}$; Reverse indicator:

$$Y_{ij}=\frac{x_{i\,max}-x_{ij}}{x_{i\,max}-x_{i\,min}} \tag{1}$$

Where: Y_{ij} is the standardized data of the indicator; x_{ij} is the raw data of the j indicator of the i region; $x_{i\,max}$ and $x_{i\,min}$ are the maximum and minimum values of the j indicator respectively.

Determination of indicator weights by entropy weighting method:

Calculate the weight of the ith sample value under the jth indicator P_{ij}:

$$P_{ij}=\frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \tag{2}$$

Calculate the information entropy of each indicator E_j:

$$E_j=-\frac{1}{\ln n} * \sum_{i=1}^{n} (P_{ij} * \ln(P_{ij})) \tag{3}$$

Calculate the information utility value D_j:

$$D_j=1-E_j \tag{4}$$

Calculate the weighting coefficient W:

$$w_j=\frac{D_j}{\sum_{j=1}^{m} D_j} \tag{5}$$

TOPSIS method to calculate the level of development of data factor marketization:

Construct the weighting matrix V:

$$V=(v_{ij})_{n\times m}=(W_j\times H)_{n\times m} \tag{6}$$

Determine the positive and negative ideal solutions for each indicator:

Positive ideal solution$V^{+}=\max[v_{1j},v_{2j},\cdots,v_{ij}]$;Negative ideal solution

$$V^{-}=\min[v_{1j},v_{2j},\cdots,v_{ij}] \tag{7}$$

Calculate the distance from each year to both solutions using Euclidean distance:

$$D_i^{+}=\sqrt{\sum_{j=1}^{m}(v_{ij}-V_j^{+})};\ D_i^{-}=\sqrt{\sum_{j=1}^{m}(v_{ij}-V_j^{-})} \tag{8}$$

Calculate the proximity of each year to the positive ideal solution C_i:

$$C_i=\frac{D_i^{-}}{D_i^{+}+D_i^{-}} \tag{9}$$

In the ninth step, C_i is the closeness of the ith year, and the value range is [0, 1]; the larger C_i is, the higher the development level of data factor marketization is, and vice versa, the smaller it is.

2.3. Analysis of Data Factor Marketization Measurement Results

The development level of data factor marketization in 2011, 2015, 2019 and 2023 in 31 provinces and cities across the country is shown in the table below. In terms of 2011 data, the first place in the score of data factor marketization development level is Guangdong Province (0.65), and the lowest score level is Tibet (0.03); from the regional perspective in 2011, the first place in the eastern, central, western and northeastern regions are Guangdong (0.65), Hunan (0.21), Sichuan (0.17), and Liaoning (0.18), respectively. The extreme differences in the scores of the East, West, Central and Northeast regions are 0.53, 0.11, 0.12 and 0.07, respectively, which initially suggests that the level of development of data factor marketization in the East region is extremely unbalanced. In terms of 2023 data, the first place in the score of data factor marketization development level is still Guangdong Province (0.69), and the lowest score is Qinghai Province (0.1); from the regional perspective in 2023, the first place in the East, Central, West and Northeast regions are Guangdong (0.69), Anhui (0.23), Sichuan (0.22) and Liaoning (0.76), respectively. The extreme differences in the scores of the eastern, western, central and northeastern regions are 0.52, 0.09, 0.14 and 0.05, respectively. The gap in the scores of data factor marketization has narrowed to a certain extent in both the eastern and the central and western regions, which may be due to the fact that after a decade's development, all the regions of the country have begun to recognize that the data factors need to be mobilized in order to give full play to their economic value, which in turn accelerates the process of marketization. marketization process.

Table 2. Data factor marketization level based on entropy weight TOPSIS measurement

Province	2011	Ranking	2015	Ranking	2019	Ranking	2023	Ranking
Beijing	0.55	3	0.63	2	0.63 2	0.59	0.59 2	2
Tianjin	0.21	9	0.20	14	0.22	0.22 14	0.20	15
Hebei Province	0.16	14	0.18	19	0.18	21	0.17	20
Shanxi Province	0.11	22	0.12	31	0.14	25	0.14	25
Inner Mongolia Autonomous Region	0.15	17	0.18	17	0.14	24	0.16	21
Liaoning	0.19	10	0.20	13	0.20	16	0.18	17
Jilin	0.12	21	0.16	22	0.15	23	0.13	27
Heilongjiang Province	0.15	15	0.16	24	0.14	26	0.12	28
Shanghai	0.36	6	0.49	3	0.45	4	0.47	3
Jiangsu	0.55	2	0.47	4	0.46	3	0.46	4
Zhejiang Province	0.50	4	0.43	6	0.43	5	0.39	5
Anhui	0.13	19	0.21	11	0.25	9	0.23	9
Fujian	0.29	7	0.29	7	0.36	6	0.28	7
Jiangxi	0.10	26	0.18	18	0.18	19	0.18	16
Shandong Province	0.36	5	0.44	5	0.36	7	0.39	6
Henan Province	0.16	13	0.24	10	0.25	11	0.23	10
Hubei	0.16	12	0.26	8	0.25	10	0.22	12
Hunan Province	0.21	8	0.20	12	0.23	13	0.21	13 0.21
Guangdong Province	0.65	1	0.65 1	1	0.67 1	1	0.69	1
Guangxi Zhuang Autonomous Region	0.12	20	0.16	21	0.19	17	0.15	24
Hainan Province	0.11	23	0.19	15	0.16	22	0.17	19
Chongqing	0.15	16	0.19	16	0.22	0.22	0.23	11
Sichuan	0.18	11	0.25	9	0.29	8	0.25	8
Guizhou	0.10	27	0.15	25	0.18	20	0.17	18
Yunnan Province	0.11	24	0.17	20	0.23	12	0.16	23
Tibet Autonomous Region	0.05	31	0.13	28	0.10	28 0.10	0.12	29
Shaanxi	0.14	18	0.16	23	0.18	18	0.20	14
Gansu	0.08	29	0.12	30	0.10	30	0.10 30	30
Qinghai Province	0.08	28	0.12	29	0.11	0.11	0.10	31
Ningxia Hui Autonomous Region	0.08	30	0.15	26	0.11	29	0.13	26
Xinjiang Uygur Autonomous Region	0.10	25	0.14	27	0.12	27	0.16	22

In order to analyze the development of data factor marketization more intuitively, the spatial distribution maps of data factor marketization at four time points, namely, 2011, 2015, 2019 and 2023, are visualized, and the development level of data factor marketization in each province is divided into three stages, namely, low, medium and high, by using natural breakpoints. In 2011, the overall level of China's data factor marketization was In 2011, the overall level of data factor marketization in China was not high, showing a pattern of high in the east, second in the center and low in the west. This may be due to the fact that the infrastructure construction in the east is better than that in the central and western regions, which is more conducive to the flow and trading of data elements. In 2015, most provinces in the western region entered the medium level, which may be due to the fact that the first big data trading platform was set up in Guiyang in 2014, and since then, a large number of data exchanges have continued to spring up in various regions of the country, and as of 2019, a large number of data exchanges have been set up, including the Shanghai Data Exchange Center, Harbin Data Exchange Center and more than 20 data trading platforms. However, due to the fact that the system of data factor marketization is still to be improved, the system of data trading is not clear enough and other issues, resulting in the development of the marketization of data factors at a relatively slow pace, from the graphical comparison of the level of marketization of data factors in 2015 and 2019, in addition to the rapid development of Sichuan in the western region, the rest of the provinces are growing slowly, and the high level of provinces in all regions of the country have not seen significant growth. From the visualization of 2023, the number of low-level provinces has sharply decreased from 12 in 2011 to 6 in 2023, and the number of high-level provinces has increased from 5 to 14 , on the whole, the level of data factor marketization in China is increasing, showing a pattern of development in which the eastern region is high, the central region is next to it, and parts of the western region and the northeast are relatively low.

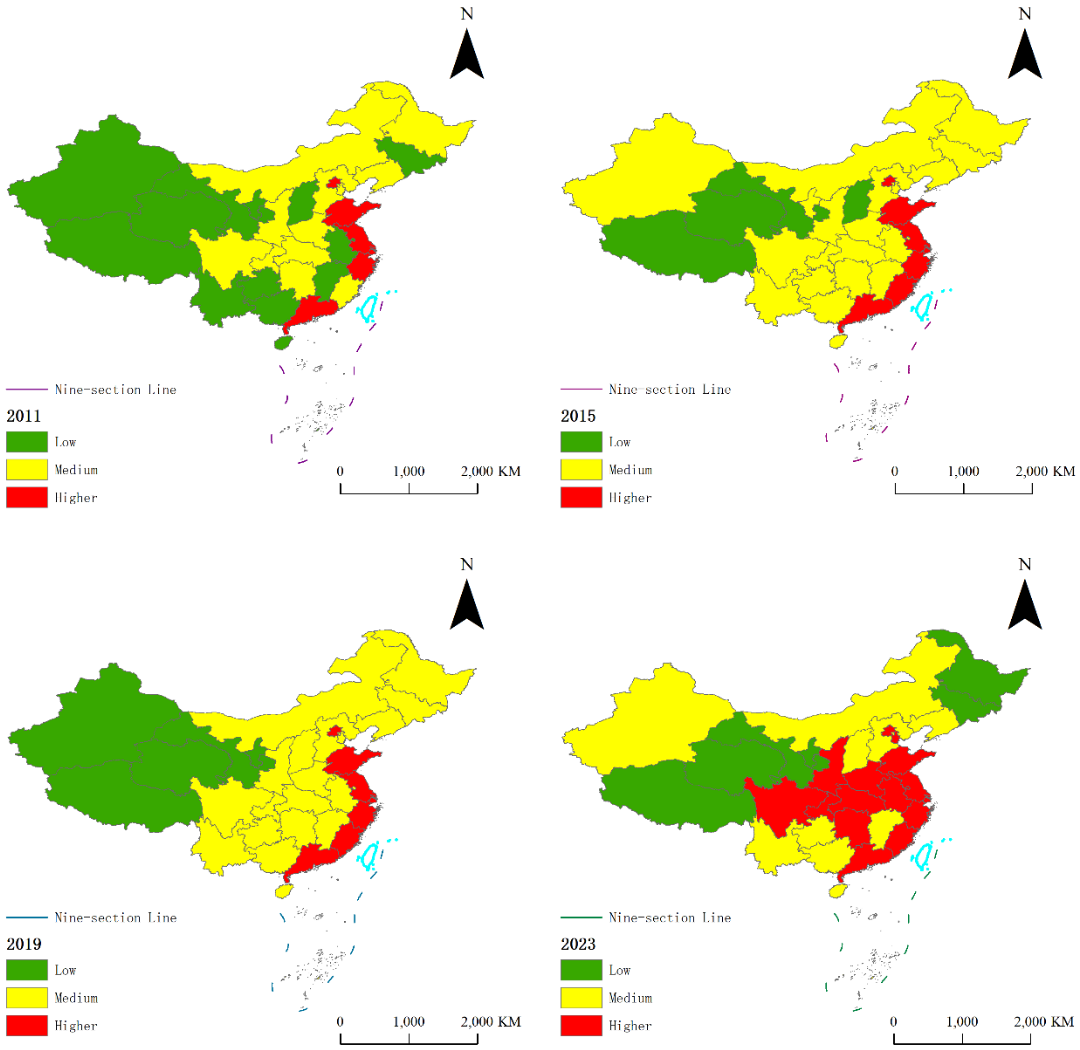

Figure 1. Development level of data factor marketization in 2011, 2015, 2019 and 2023

3. Eigen Microstate Construction and Spatio-Temporal Analysis of Data Factor Marketization

Although the development level of data factor marketization in China's 31 provinces has been measured using the entropy weight TOPSIS method in the previous section, its core drivers as well as spatial characteristics have yet to be explored in depth. Based on this, this brief considers data factor marketization in cities as a dynamic and complex system, and analyzes the spatial characteristics of data factor marketization over multiple periods of time using the intrinsic microstate method.

3.1. Construction and Solution of Data Factor Marketization Microstate

Complex systems are prevalent in nature and human social life, including thermodynamic systems, condensed matter, active matter, climate systems, etc., and are an important basis for the theory of system science [19]. The method of intrinsic microstates can analyze the phase transition and critical phenomena of complex systems on the one hand, and identify the phase transition and universality classes of systems on the other [20]. It has been successfully applied to the study of surface temperature and the time evolution mechanism of collective behavior [21]. The eigenmicrostates can integrate the overall information of data factor marketization and the city at all points in time, and represent the main features of data factor marketization in the evolution process. Generally speaking, the higher the contribution of an eigenmicrostate, the more obvious the features corresponding to that unchanged state are in the whole time period.

Based on the above analysis, this paper constructs the microstates of data factor marketization, and the specific construction method and solution process are as follows:

This paper focuses on the changes of data factor marketization in 31 provinces in China from 2011 to 2023, so each province is taken as a unit, and all units constitute a replication system. The value of the data factor marketization level of cell$i$ at time$t$ is denoted as$O_i(t)$, the mean value of cell i during the study period is denoted as $\overline{O_i}=\frac{1}{T}\sum_{t=1}^{T} O_i(t)$, and the fluctuation of the data factor marketization level at time i at t is denoted as $\delta O_i(t)=O_i(t)-\overline{O_i}$. The time series of standard deviation of data factor marketization of cell i is denoted as $\sqrt{[\delta O_i(t)]^2}$, and the micro-state cross-section of data factor marketization at the time of t can be expressed as follows.

$$S(t)=S_1(t), S_2(t), S_3(t), \ldots, S_n(t) \tag{10}$$

$$S_1(t)=\frac{\delta O_i(t)}{\sqrt{[\delta O_i(t)]^2}} \tag{11}$$

Combined with the microstate definition of data factor marketization, its complex system can be expressed as a A_{it} matrix, which is calculated as follows:

$$A_{it}=\frac{S_i(t)}{\sqrt{\sum_{i=1}^{n}\sum_{t=1}^{T} S_i(t)^2}} \tag{12}$$

Using the singular value decomposition matrix A_{it} matrix, the following result can be obtained:

$$A=U\cdot\Lambda\cdot V^T=\sum_{j=1}\lambda_j u_j\times(v_j)^T \tag{13}$$

Where U and V are orthogonal matrices, and λ_j is the diagonal value of the matrix Λ, and their sizes are arranged in the order of $\lambda_{j1}\geq\lambda_2\geq\ldots\lambda_T$. Combined with the definition of intrinsic microstates, the correlation matrix can be expressed as $C=C_0A\cdot(A)^T$, which is calculated as shown below:

$$\frac{C}{C_0}\cdot u_j=\lambda_j^2 u_j \tag{14}$$

Among them, the variable of focus is $(\lambda_j)^2$, which represents the contribution rate of the j th eigenmicrostate, and u_j denotes the j th eigenmicrostate emergence. Further, v_j can be used to represent the evolution of the j th eigenmicrostate:

$$S_j^e=\sum_{i=1}^{N} S_i u_{ij}=\lambda_j v_j \tag{15}$$

3.2. Spatial Characterization of Microstates of Data Factor Marketization

The intrinsic microstates represent the main characteristics of the system in the process of change, including three subjects: the characteristics, the contribution of the characteristics to the overall change, and the evolution. In this study, firstly, python software is used to realize the solution of the above microstate equation, and the obtained results are saved in CSV format for storage; secondly, mapping software is used to analyze the cumulative contribution rate of the eigenstates and the trend of the temporal change; and finally, ArcMap software is used to realize the spatial mapping of the eigenstates.

On the basis of the above analysis, this study calculates the contribution degree and evolution sequence of the eigenmicrostates of data factor marketization, and ranks the contribution degrees from the largest to the smallest, and selects the set of eigenmicrostates with a cumulative contribution rate of more than 70% for further discussion.

3.2.1. Contribution rate of eigen microstates

From the figure below, it can be seen that the contribution rate of the first eigenmicrostate of the Data Factor Marketization Index is 48%, the contribution rate of the second eigenmicrostate is 18%, and the contribution rate of the third eigenmicrostate is 12%; the cumulative contribution rate of the first three eigenmicrostates is more than 78%, which suggests that the first three eigenmicrostates can be representative of the overall pattern of development, but there is still a probability that the first three eigenmicrostates may not follow the trend of 22%. Specifically, the first eigenmode represents the core driving force for the construction of data factor marketization, which in reality is reflected in the policy synergy effect of individual provinces; the second eigenmode reflects the regional gradient development difference, which is consistent with the development pattern analyzed in the previous section of high in the east, followed by the center and the west, and low in the northeast as well as a few parts of the west; and the third eigenmode represents the unique local innovation pilot path, which in reality is reflected in the big data trading platform. The third eigenmicrostate represents unique local innovation pilot paths, which in reality are reflected in pilot policies such as big data trading platforms, comprehensive big data pilot zones, and data management bureaus.

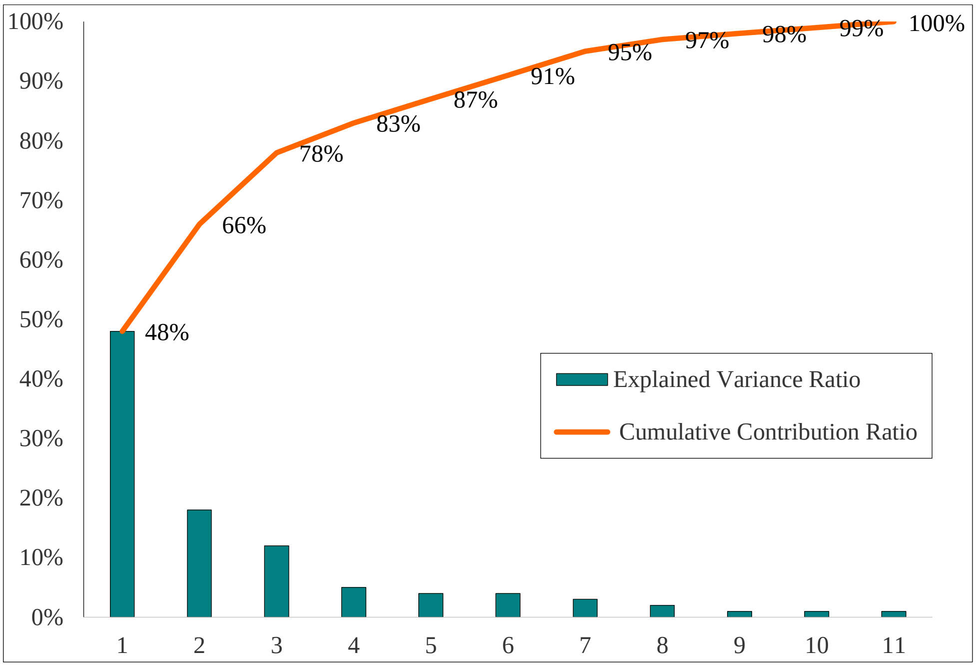

Figure 2. Cumulative Contribution of Intrinsic Microstates

3.2.2. Evolution of Eigenmicrostates

This paper further discusses the changing law of the main features of China's data factor marketization and analyzes the equilibrium state and stable phase transition of its main features in the process of change by plotting the sequence of eigenmicrostates' evolution with a single contribution rate of more than 10%.

Specifically, during the period from 2011 to 2014, the value of the first eigenmicrostate was positive, which coincided with the strengthening of the national strategic leadership, reflected in the development strategies such as the construction of Broadband China; in 2015, the value turned from positive to negative, which was mainly due to the State Council's issuance of the "Outline of Action for the Promotion of the Development of Big Data", which broke the government-led development model; from 2020 onwards, the negative value went back to rise, which was mainly due to the issuance of the "Twenty Articles on Data", which was the first step in the development of China's data factor market. The release of "Twenty Articles on Data" accelerated the marketization process of data elements nationwide. On the whole, the microstate of the first eigenvalue decreases from 0.5 in 2011 to -0.2 in 2023, indicating that the national strategy is gradually weakened in the process of data factor marketization.

From 2011 to 2015, the value of the second eigen microstate is decreasing, indicating that the regional development differentiation is shrinking, which may be due to the fact that strategies such as Broadband China are slowly spreading to all provinces, which constantly shrinks the differences between the infrastructures of provinces; from 2015 to 2019, the value of the second eigen microstate is increasing, which may be due to the fact that since 2014, a small portion of the regions started the pilot policy of data trading platform to accelerate the development gap of data factor marketization in each region, but few regions set up data trading platforms after 2018 due to various reasons such as the imperfect system of data trading; starting from 2020, the value of the second intrinsic microstate is decreasing, which represents the further reduction of the differences between the regional development, which is mainly due to the fact that, in 2020, the marketization of data factors was written into the national policy documents for the first time, which is mainly due to the fact that, in 2020, the marketization of data factors was written into the This is mainly due to the fact that in 2020, the marketization of data elements was written into national policy documents for the first time, and all regions of the country began to accelerate the process of its marketization, and at the same time, since the system of data trading has been basically established, all provinces have set up big data trading platforms, which shortens the development differences of data element marketization.

The third eigenmode microstate started to grow from a negative value in 2014, and then continued to grow in 2016, corresponding to the construction of the first batch of big data trading platforms in 2014, and the establishment of national-level big data comprehensive experimental zones in 2016; there was a downward trend in 2018, consistent with the decline in the number of big data trading platforms analyzed above; after 2020, the third eigenmode microstate started to grow, and in 2023 it reaches the highest level in history, indicating that the regional innovation and development model is more capable of influencing the development process of data factor marketization.

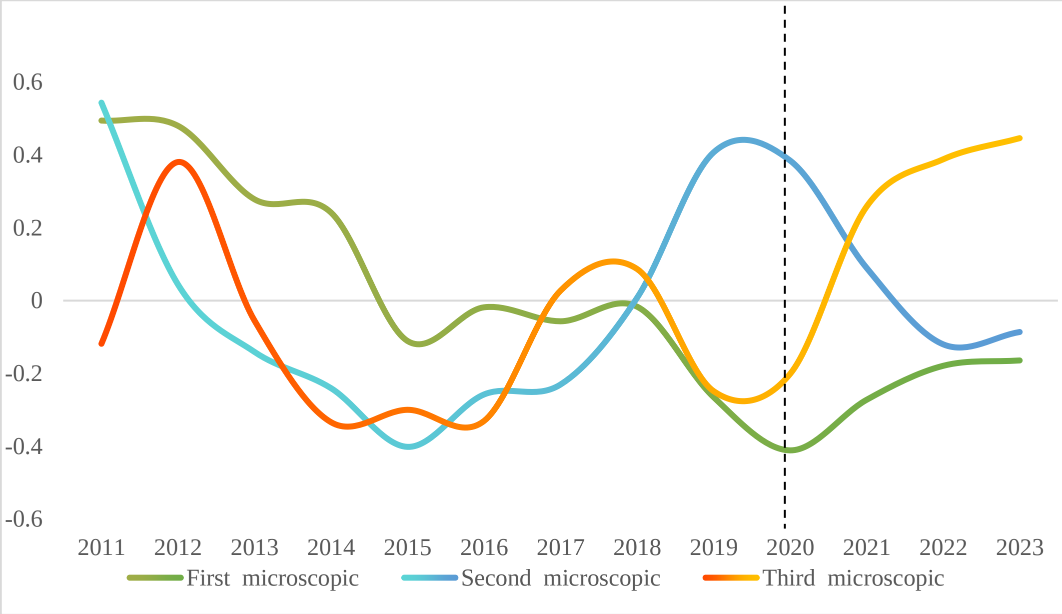

Figure 3. Evolutionary sequence of eigenmicrostates

3.2.3. Mapping of Eigenmicrostates

In this paper, the spatial mapping of eigenmicrostates is obtained by setting the values of eigenmicrostates of data factor marketization in each cell. The following figure shows the first, second and third eigenmicrostates of data factor marketization, in which the value domain of the first eigenmicrostate is [-197 161.3], that of the second eigenmicrostate is [-163 150.6], and that of the third eigenmicrostate is [-218 137.7], and it is found that, in comparison, the value domain of the first eigenmicrostate is the largest, and that of the third eigenmicrostate is the second largest, and the second eigenmicrostate is the third largest. second, and the value domain of the second eigenmode microstate is the smallest, indicating that the main influencing factors of data factor marketization have higher complexity. From the first eigenvalue microstate mapping, the high value region is mainly concentrated in the eastern and northeastern regions, and the low value region is reflected in some regions in the western part of the country. From the second eigenmode microstate mapping, the high value areas are reflected in the eastern and central regions, and the low value areas are concentrated in the western and northeastern regions; this is almost the same as the level of economic development and the level of infrastructure development. In terms of this third eigen microstate mapping, the low-value regions are concentrated in the Northeast region, and the high-value regions have no distinctive features; the third eigen microstate represents the regional innovation and development mode, which may indicate that the innovation mode in the Northeast region fails to provide effective momentum for the development of data factor marketization.

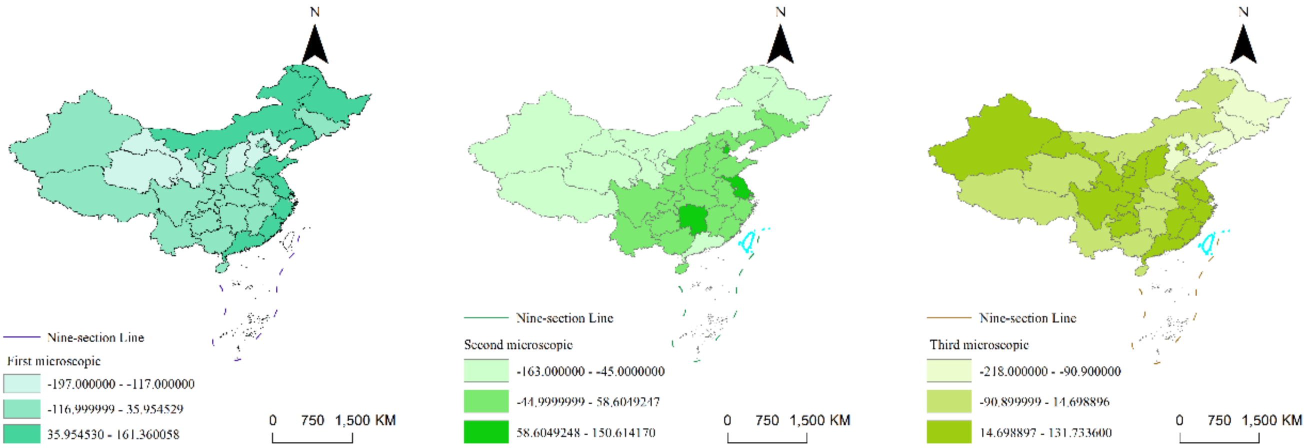

Figure 4. Eigenmicrostate mapping of data factor marketization

4. Research Conclusions and Policy Recommendations

4.1. Research Conclusion

Through the above analysis, the following research conclusions are obtained: First, from the data of 2011 to 2023, the level of China's data factor marketization has been improved obviously, but the differences between regions are gradually appearing, on the whole, the level of the eastern region is higher than that of the western region, but part of the western region is higher than the central and eastern regions due to its unique geographic location and development situation, which leads to the level of the development of the marketization of data factors. Secondly, from the point of view of the contribution rate of the intrinsic microstate, the development of China's data factor marketization presents three main development modes, one is the core driving force for the construction of data factor marketization, which is embodied in reality as the synergistic effect of the policies of individual provinces; the second is the development mode of the regional gradient difference, and the third is the unique local innovative pilot path, which is embodied in reality as the pilot policies such as the big data trading platform, the big data comprehensive pilot zone and the data Administration and other pilot policies. Third, from the perspective of the time evolution of the intrinsic microstate, the impact of different policies will have an impact on the development level of data factor marketization. Fourth, from the perspective of the eigenmode mapping, the policy synergy effect is strongest in the east and northeast, and slightly weaker in the west; the difference in the gradient development of data factor marketization is strong in the central and eastern regions, and slightly weaker in the western and eastern regions; the differentiated policies in the west and east better build the level of data factor marketization.

4.2. Policy Recommendations

Combining the theoretical analysis and evaluation results, the following policy recommendations are drawn: first, implement regional classification guidance and precise policy to promote coordinated development. On the one hand, a national-level regional development assessment system for data factor marketization can be established, and development indexes and classification reports can be released regularly to accurately identify the development stages, advantages and shortcomings of each region and province; on the other hand, support can be focused on exploring differentiated policies and innovative pilots in the western region, such as cross-border data flow, linkage of green data centers and arithmetic hubs, and the valorization of data in characteristic industries, etc., so as to avoid simple copying of the eastern model. Second, strengthen the synergy of the policy system. Second, strengthen the synergy, systematicity and dynamic adaptability of the policy system. At the national level, improve the data foundation system and strengthen the coordination of top-level design; at the regional level, establish a regularized policy coordination and joint action mechanism; and at the local level, encourage inter-provincial and inter-municipal pilots to carry out special policy coordination around specific scenarios. Third, deepen the theoretical research on development models and the promotion of model adaptation. Support academics to conduct in-depth research on the intrinsic mechanism, conditions of application, key success factors and potential risks of the three development models, with a focus on exploring the boundaries of the effectiveness of different models in different regions and at different stages of development; and support localities in exploring the fusion and innovation of the different models, for example, embedding a policy synergy mechanism into the regional gradient development or integrating the gradient development idea into the innovation pilot, so as to form a more viable and composite development path. Fourth, improve the market-oriented development of data elements. Fourth, improve the monitoring and evaluation of the market-oriented development of data elements and the knowledge-sharing system. First, a unified and standardized core indicator system can be constructed to ensure the scientificity, continuity and comparability of data; second, a national data factor market development observatory can be set up to integrate data from multiple sources, monitor in real time the development dynamics of key dimensions such as the scale, structure, efficiency and fairness of data factor marketization in the whole country and regions, and release authoritative reports on a regular basis, so as to provide a solid data foundation for policy formulation and academic research. The report provides a solid data foundation for policy formulation and academic research.

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