

Study on the Measurement of the Level of Development of the Digital Economy and the Structure of Spatial Networks

Yuhong Yang *, Aiyin Wang, Chenchen Liu, Chu Chu

School of Statistics and Data Science, Xinjiang University of Finance and Economics, Urumqi Xinjiang, 830012, China

* Corresponding author: Yuhong Yang

Abstract: Based on the provincial panel data from 2013-2021, the entropy weight method is used to measure the comprehensive development index of the digital economy, and the gravity model and social network analysis are used to examine the spatial correlation network structure characteristics of the digital economy. digital economy, and the gravity model and social network analysis are used to examine the spatial correlation network structure characteristics of the digital economy among provinces and regions. The study found that: (1) the overall digital economy development level of China's provinces and municipalities is on the rise, but the overall digital economy development level of China's provinces and municipalities is not as high as it should be. municipalities is on the rise, but there is a large gap in the level of digital economy development between regions, and the level of development is gradually declining from China's eastern region to the western region; (2) the spatial network structure of China's level of digital economy development has a better robustness, and development has a better robustness, and the spatial correlation on the whole is strengthened, but the speed of development is relatively slow, and at the same time, the spatial network hierarchical structure is more rigid, and regions under different geographic locations and different levels of development are likely to have spatial network hierarchical structure. development is likely to have spatial interaction effects. (3) The distribution pattern of "core-edge" is formed among provinces and regions, with the distribution pattern of "core-edge" is formed among provinces and regions, with Shanghai, Beijing, Sichuan, Anhui, Shandong, Guangdong, Jiangsu, Henan, Zhejiang, Hubei and Shaanxi being at the core of the network, with strong aggregation and radiation ability. The distribution pattern of "core-edge" is formed among provinces and regions, with Shanghai, Beijing, Sichuan, Anhui, Shandong, Jiangsu, Henan, Zhejiang, and Hubei being at the core of the network, with strong aggregation and radiation ability.

Keywords: Digital Economic Development; Entropy Power Method; Spatial Network Structure; Social Network Analysis.

1. Introduction

In recent years, under the influence of the new crown epidemic, the real economy has been impacted, while the digital economy seems to be a new force, bursting with tenacious vitality. According to the Report on the Development of China's Digital Economy (2022) released by the China Communications Academy in 2022, the total scale of China's digital economy reached 45.5 trillion yuan in 2021, with a nominal year-on-year growth of 16.2% compared to 2020, and its proportion in GDP reached 39.8%, 1.2 percentage points higher than that in 2020, and has already become an important force in stabilizing economic growth and promoting national economic development.

The digital economy, with digital technology at its core, breaks through the limitations of geographic space and time, breaks down information barriers and realizes the instant sharing of information through digital technologies such as big data, the Internet of Things and intelligentization. At the same time, the development of e-commerce platforms based on digital technology has spawned new business models, provided more employment and entrepreneurial opportunities, and facilitated the full flow of technology, networks, talent, and other resource elements. However, due to the relatively weak digital infrastructure in some areas, the residents' digital literacy and ability to utilize digital technology are relatively low, which is prone to form an inter-provincial digital divide and continuously widen the gap, which is not conducive to the healthy development of the digital economy. Therefore, an in-

depth study of the current level of development of the digital economy and the characteristics of the spatial network structure is of great significance for the government to formulate differentiated policies to bridge the digital divide and optimize the pattern of balanced development of the digital economy.

2. Literature Review

The current research on digital economy is mainly carried out from three aspects. First, the connotation of the digital economy, some scholars from the perspective of data and information related industries, that the digital economy is based on communication technology and informatization, digital data as the key production factors, through the Internet, the Internet of Things and other platforms to integrate information and communication and Internet technology in the traditional economic relations, and ultimately to realize the digitization of economic activities[1-3]. There are also some scholars from the perspective of digital technology, that the digital economy is driven by the continuous development and innovation of digital technology to promote the development of digital productivity, and then by the development of digital productivity to promote the change of production relations, giving rise to a new economic form that is the digital economy[4][5]. Secondly, the measurement of digital economy, most scholars through the construction of evaluation index system for its measurement analysis, such as Wang Jun et al.[6] based on the connotation of the digital economy and the environmental background, from the digital

economy development carrier, development environment, digital industrialization, industrial digitalization of the four dimensions of the selected 30 indicators to build the evaluation index system, the entropy weight method for measurement; Zhang Hong et al.[7] based on the concept of high-quality development definition of the digital economy, the establishment of the digital economy, including efficiency and efficiency, the concept of the digital economy, the digital economy, the digital economy, the digital economy, the digital economy, the digital economy and the digital economy. defined the connotation of digital economy based on the concept of high-quality development, established an evaluation index system containing 38 indicators in five dimensions, namely, efficiency, innovation, fairness, sustainability and industrial development, and measured the level of high-quality development of digital economy in each province in China by using entropy weight method. Some scholars have also measured the scale of digital economy development by compiling the Digital Economy Satellite Account[8][9] and measuring the value added of industries[10][11]. Thirdly, the impact of digital economy, through combing the relevant literature, we found that most of the research focuses on the impact of digital economy on economic development[12][13], environmental quality[14][15], resource allocation[16][17], employment structure[18-20] and other aspects of the research.

Based on this by constructing a multi-dimensional evaluation index system, the entropy weight method is used to measure the development level of China's digital economy, and at the same time, the gravitational model and social network analysis are used to examine the structural

characteristics of the spatial correlation network of the digital economy among the provinces and regions. The marginal contributions are: first, using the modified gravity model to calculate the associative relationship of the digital economy development level between provinces and domains, and constructing the network of China's digital economy development level to measure the strength of the relationship between the two provinces and domains before the two; second, introducing the social network analysis method, utilizing the gravity model to construct the spatial network of China's digital economy development level, and abstracting the 30 provinces and domains as nodes, and the associative relationship as edges, the Thus, the overall network association analysis and individual network characteristics are analyzed, aiming to provide reasonable countermeasure suggestions for promoting the synergistic development of different regions of China's digital economy and optimizing the spatial layout of digital economy from the perspective of relationship and network.

3. Research Design and Data Sources

3.1. Construction of the Indicator System

At present, the measurement system about digital economy has not yet reached an agreement, drawing on the way of selecting indicators of Wang Jun et al. [6] are selected from 5 dimensions of digital infrastructure, digital industrialization, industrial digitization, digital innovation, digital finance, and the digital economy development index of each province and city is measured by entropy method, and the specific evaluation index system is shown in Table 1.

Table 1. Digital economy evaluation index system

Level 1 indicators	Secondary indicators	Tertiary indicators	unit (of measure)	causality	weights
Digital Economy Development Index	digital infrastructure	Internet broadband access ports per capita	Pcs/person	+	0.0159
		Number of domain names per capita	Pcs/person	+	0.0813
		Cell phone penetration rate	Departments/100 persons	+	0.0150
		Fiber optic line length	kilometer	+	0.0306
	digital industrialization	Employed in urban units of the information transmission, software and information technology services industry	all the people	+	0.0621
		Number of enterprises in the electronic information manufacturing industry	billions	+	0.0980
		Total postal operations	billions	+	0.1037
		Total telecommunication services	billions	+	0.0638
	Industrial digitization	Number of websites owned by enterprises	unit	+	0.0500
		E-commerce sales	billions	+	0.0706
		Computers per 100 persons in enterprises	unit	+	0.0236
		Share of enterprises with e-commerce trading activities	%	+	0.0148
	Digital Innovation	Full-time equivalents of R&D personnel in industrial enterprises above designated size	man-year	+	0.0718
		Number of new product projects of industrial enterprises above designated size	unit	+	0.0829
		Domestic Patent Applications Received	unit	+	0.0671
		Technology market turnover	billions	+	0.0987
	digital finance	breadth of coverage	/	+	0.0150
		Depth of use	/	+	0.0190
		Degree of digitization	/	+	0.0159

3.2. Research Methodology

3.2.1. Entropy Weight Method

Entropy weight method is a method to objectively evaluate the assignment of indicators based on the degree of variability of the indicators, the greater the degree of variability of the indicators, the more information is reflected, and the greater the corresponding weights are. It has high precision and can reduce the human subjective factors [21], and has the advantages of truthfulness, objectivity, reliability and so on. The main steps are as follows:

(1) To eliminate the influence of indicator units and their numerical orders of magnitude, the indicator data are standardized:

Positive indicators

Negative indicators

where is a normalized value indicating the maximum value of the first indicator in all years and the minimum value in all years.

(2) Calculate the share of indicator No. 1 for the first year.

(3) Calculate the entropy value of the indicator.

(4) Calculate the redundancy of the entropy value.

(5) Calculate the weights of the evaluation indicators.

(6) Calculation of a composite index of the level of development of the digital economy.

3.2.2. Gravitational Modeling

Constructing the network of China's digital economic development level requires measuring the strength of the relationship between the two provinces, according to the research of previous scholars, this paper chooses the gravity model to portray its spatial correlation relationship, the gravity model is derived from the universal gravitation model in traditional mechanics. 1942 Zipf introduced the modified gravity model for the first time in the study of the analysis of interconnection between the cities, since then, many scholars. Since then, many scholars have made different assumptions on the model based on the specificity and difference of the research problem, and gradually formed a more mature economic theory system nowadays, which is widely used in the research of regional spatial interconnection[22]. The formula is:

Where, denotes the strength of association between the level of digital economic development of the province; and are the level of new urbanization development of the province and the province respectively; denotes the geographic distance between the province and the province; and denotes the contribution of the province to the linkage between the level of digital economic development of the province.

According to the above formula, the correlation relationship between the level of digital economic development among provinces and regions is calculated, and the gravity matrix is constructed, taking the average value of each row in the matrix as the threshold value of the row, in which if it is larger than the threshold value, it is recorded as 1, and if it is smaller than the threshold value, it is recorded as 0.1 indicates that there is a correlation relationship between the rows and the columns of the location and the provinces, while 0 indicates that there is no correlation, so as to construct the adjacency matrix of a spatial network.

3.2.3. Social Network Analysis

Social Network Analysis (SNA) is a method that reflects the structure of the network and its attribute characteristics through the study of network node relationships. The spatial

network of China's digital economy development level is constructed by using the gravity model introduced in the previous section, which abstracts the 30 provinces and regions as nodes, and the association relationship as edges. From there, the overall network association analysis and individual network characteristics are analyzed.

(1) Overall network correlation analysis

The correlation analysis of the overall network is mainly analyzed in terms of four indicators: network density, connectivity, hierarchy and efficiency. Network density is calculated by the ratio of the existing edges to the potential edges in the network, which indicates the strength of the linkage of the development level of new urbanization between various provinces and regions in the country; the higher the network density, the closer the linkage between provinces and regions, and vice versa. The network relevance, network level and network efficiency are measures of the stability of the network.

(2) Individual network characteristics

Individual network characteristics are mainly described by degree centrality, proximity centrality and mediation centrality to reveal the position and role played by each province in the country. Degree centrality in a spatial network is a description of the position of a node in the network, if the higher the degree of a node, the more centrally located it is in the network, the more important it is in the network. Proximity centrality is an evaluation of how easy it is for a spatial network to produce an association relationship. Mediation centrality is a description of the control power of a spatial network.

(3) Data sources

Balanced panel data of 30 provinces (excluding Tibet, Hong Kong, Macao and Taiwan) from 2013-2021 are selected for the analysis, in which the digital finance data come from the Digital Finance Research Center of Peking University, and the other data come from the China Statistical Yearbook, the China Statistical Yearbook of the Electronic Information Industry, the EPS database, and the provincial and municipal statistical yearbooks, and some of the missing data are made up by linear interpolation method.

4. Empirical Analysis

4.1. Measurement and Analysis of the Level of Development of the Digital Economy

The entropy weight method is applied to measure the level of digital economy development of 30 provinces (except Tibet and Hong Kong, Macao and Taiwan) in China from 2013 to 2021, and the comprehensive index and ranking of digital economy are shown in Table 2. The measurement results show that the comprehensive index of China's digital economy improves from 0.071 in 2013 to 0.203 in 2021, with an average annual growth rate as high as 14.03%, indicating that China's digital economy is booming. Meanwhile, the overall development of digital economy in various provinces and cities also shows an upward trend, such as Beijing's Digital Economy Composite Index has steadily increased from 0.220 in 2013 to 0.552 in 2021, with an average annual growth rate of 12.19%; Anhui's Digital Economy Composite Index has steadily increased from 0.059 in 2013 to 0.207 in 2021, with an average annual growth rate of 16.99%; Yunnan's Digital economy composite index from 0.028 in 2013 to 0.104 in 2021, with an average annual growth of

17.82%. However, there is still a large gap in the level of digital economy development between provinces, for example, in 2021, Guangdong's digital economy composite index of 0.700, while Ningxia's digital economy composite index is only 0.071, at the same time, the level of development is gradually declining from China's eastern coastal areas to the western inland areas, the provinces in the eastern region exceeding the national digital economy development composite index accounted for 70% of the provinces, the central region accounted for 20%, and the Western region

accounts for 10%. In the comprehensive ranking Guangdong, Beijing, Jiangsu, Zhejiang, with their superior geographic location, rich digital resources and solid social foundation, etc., the level of digital economy development is in the forefront; Shanghai, Shandong, Fujian, Sichuan followed, while Xinjiang, Gansu, Ningxia, Qinghai due to the geographic environment, economic foundation, social resources and other conditions of the limitations of the level of development of the digital economy in the end.

Table 2. Comprehensive index and ranking of China's digital economy, 2013-2021

	2013	rank	2014	rank	2015	rank	2016	rank	2017	rank	2018	rank	2019	rank	2020	rank	2021	rank
Shanghai	0.134	6	0.164	5	0.195	5	0.216	5	0.232	5	0.256	5	0.288	5	0.316	6	0.365	5
Yunnan	0.028	22	0.037	21	0.057	21	0.061	19	0.070	20	0.089	19	0.110	19	0.122	20	0.104	21
Inner Mongolia	0.029	20	0.035	24	0.052	22	0.058	23	0.064	25	0.070	26	0.084	26	0.093	25	0.093	24
Beijing	0.220	3	0.253	3	0.313	1	0.354	2	0.380	2	0.407	2	0.460	2	0.488	2	0.552	2
Jilin	0.027	24	0.034	25	0.051	24	0.057	24	0.067	22	0.081	23	0.091	25	0.098	24	0.087	26
Sichuan	0.071	8	0.087	8	0.112	8	0.124	8	0.148	8	0.181	8	0.212	8	0.240	7	0.223	7
Tianjin	0.055	13	0.068	13	0.091	13	0.097	13	0.099	15	0.114	17	0.132	16	0.150	16	0.156	15
Ningxia	0.014	29	0.023	29	0.041	29	0.040	29	0.049	29	0.060	29	0.062	29	0.068	29	0.071	30
Anhui	0.059	12	0.075	11	0.097	11	0.110	10	0.125	10	0.154	10	0.177	10	0.200	10	0.207	9
Shandong	0.136	5	0.150	6	0.173	6	0.193	6	0.214	6	0.253	6	0.268	6	0.321	5	0.344	6
Shanxi	0.030	19	0.037	22	0.051	23	0.056	25	0.065	24	0.086	20	0.093	23	0.104	22	0.099	22
Guangdong	0.247	2	0.272	1	0.312	2	0.365	1	0.442	1	0.551	1	0.646	1	0.739	1	0.700	1
Guangxi	0.025	25	0.035	23	0.050	25	0.058	21	0.065	23	0.084	21	0.107	20	0.124	19	0.126	19
Xinjiang	0.024	26	0.029	27	0.046	27	0.045	27	0.051	28	0.066	27	0.075	28	0.084	27	0.083	27
Jiangsu	0.248	1	0.255	2	0.282	3	0.302	3	0.330	3	0.377	3	0.429	3	0.481	3	0.466	3
Jiangxi	0.028	23	0.040	19	0.059	19	0.064	18	0.084	18	0.107	18	0.130	18	0.146	18	0.140	18
Hebei	0.048	16	0.056	17	0.075	17	0.084	16	0.098	16	0.123	15	0.148	14	0.172	14	0.157	14
Henan	0.061	11	0.074	12	0.095	12	0.106	11	0.121	11	0.149	11	0.171	11	0.194	11	0.170	13
Zhejiang	0.173	4	0.192	4	0.236	4	0.265	4	0.294	4	0.352	4	0.417	4	0.480	4	0.448	4
Hainan	0.028	21	0.038	20	0.061	18	0.058	22	0.071	19	0.079	24	0.095	22	0.093	26	0.091	25
Hubei	0.066	10	0.081	10	0.107	9	0.118	9	0.134	9	0.160	9	0.190	9	0.205	9	0.206	10
Hunan	0.049	15	0.059	15	0.077	15	0.087	15	0.103	14	0.127	13	0.155	13	0.178	12	0.174	12
Gansu	0.018	28	0.026	28	0.045	28	0.044	28	0.051	27	0.063	28	0.075	27	0.084	28	0.081	28
Fujian	0.076	7	0.089	7	0.118	7	0.146	7	0.189	7	0.206	7	0.219	7	0.207	8	0.208	8
Guizhou	0.019	27	0.030	26	0.047	26	0.054	26	0.064	26	0.082	22	0.101	21	0.110	21	0.108	20
Liaoning	0.070	9	0.083	9	0.100	10	0.098	12	0.108	13	0.125	14	0.141	15	0.154	15	0.147	16
Chongqing	0.041	17	0.056	16	0.075	16	0.084	17	0.095	17	0.116	16	0.130	17	0.146	17	0.145	17
Shanxi	0.051	14	0.065	14	0.085	14	0.095	14	0.110	12	0.132	12	0.160	12	0.176	13	0.177	11
Qinghai	0.011	30	0.016	30	0.038	30	0.038	30	0.044	30	0.055	30	0.061	30	0.067	30	0.071	29
Heilongjiang	0.037	18	0.045	18	0.059	20	0.060	20	0.070	21	0.078	25	0.092	24	0.103	23	0.095	23
nationwide	0.071		0.084		0.107		0.118		0.135		0.159		0.184		0.205		0.203	

4.2. Spatial Network Characteristics of the Level of the Digital Economy Analysis

On the basis of obtaining the comprehensive index of digital economy, firstly, according to the modified gravity model, the spatial correlation relationship of digital economic development is calculated and the relationship matrix is constructed, and secondly, the ucinet software is utilized to calculate the network density, network connectivity, network efficiency and network grade of the spatial network of the level of digital economic development of the 30 provinces in the country in the period of 2013-2021, so as to illustrate the overall network structure characteristics of the spatial network of the level of digital economic development in the

four aspects from four aspects. development level spatial network's overall network structure characteristics. Finally, we will study the five individual network characteristics of each province in the spatial network of digital economy development level in 2021, namely, out degree, in degree, degree centrality, proximity centrality and intermediate centrality, and analyze the position of each region in the network.

(1) Analysis of the overall network correlation of China's digital economy

The trend of the overall structural characteristics of the spatial network of the digital economy development level of 30 provinces in China from 2013 to 2021 is shown in Fig:

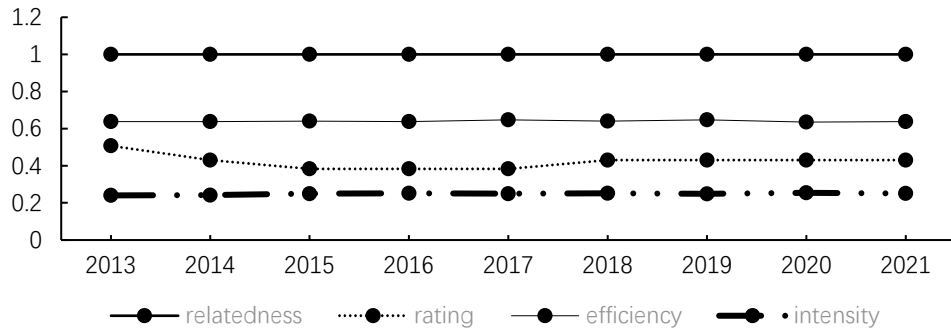


Figure 1. Line graph of the time series evolution of the overall characteristics of the national space network (2013-2021)

According to Table 3 and Figure 1, it is found that for the overall density of the network, the density of the spatial network of the level of digital economic development in China from 2013 to 2021 shows a small cyclic increase, with the density of the spatial network in 2013 being 0.240, and the density of the network reaching 0.252 in 2016, and ups and downs occurring between 2017-2021, with the highest density of the network in 2020, which indicates that the national Digital economy development level spatial network overall spatial correlation is strengthened, but the development speed is very slow. The network correlation degree is maintained at 1 steadily during the 9-year period, indicating that the structure of the spatial network of China's digital economy development level has a good robustness. The network rank degree shows a first decline and then growth, from 2013-2017 from 0.508 to 0.383 in 2017, and from 2018 it starts to grow, and the network rank degree is 0.430 in 2021, and the network rank degree has been 0.430 in the last 4 years, but the network rank degree is smaller, indicating that China's digital economy development gradually breaks through the limitations of space. The synergistic effect of digital economy among regions is more prominent. Network efficiency was 0.638 in 2013, with small fluctuations in 9 years, returning to 0.638 in 2021, with the highest value of 0.648 in 2017 and 2019 during the 9-year period, and the lowest value of 0.636 in 2020, making the network structure more stable. Comprehensive trend of the above indicators can be seen, the overall structure of the spatial network of China's digital economy development level is relatively stable, the change is not obvious, the network density has increased, the provinces and regions gradually break through the spatial limitations, but there are still differences in the development of the provinces and regions, and gradually realize the coordinated development of the digital economy in the region.

Table 3. Characterization of the overall structure of the national space network (2013-2021)

vintages	intensity	relatedness	rating	efficiency
2013	0.240	1	0.508	0.638
2014	0.241	1	0.430	0.638
2015	0.249	1	0.383	0.640
2016	0.252	1	0.383	0.638
2017	0.249	1	0.383	0.648
2018	0.252	1	0.430	0.640
2019	0.248	1	0.430	0.648
2020	0.254	1	0.430	0.636
2021	0.251	1	0.430	0.638

(2) Analysis of the centrality of China's digital economy

network

The out-degree, in-degree, point-degree centrality, proximity centrality and intermediary centrality indexes of each provincial domain are measured by using ucinet software to analyze their position and role in the spatial network of digital economic development level. As shown in Table 4:

First of all, from the point degree of centrality, the point degree of centrality is used to determine whether the region is in the center of the spatial network of the level of digital economic development. 2021 China's point degree of centrality of the spatial network of the digital economy of the average value of 40.460, 12 provinces and regions exceeded the average value, ranking in the top six provinces and regions of Jiangsu, Guangdong, Shandong, Zhejiang, Beijing, Shaanxi, the six provinces and regions of the digital economy vitality compared to the relatively vigorous, infrastructure support is relatively more perfect, and the digital economy of the surrounding provinces is better developed, thus being in the center of the digital economy development, with a strong aggregation capacity; while Inner Mongolia, Heilongjiang, Jilin, Hainan and other provinces and regions of the center of the point of the degree of low, due to the relative remoteness of these areas and the development of the digital economy is relatively slow, so that the digital economy network in these provinces and regions in the country is in the relatively marginal position in the national digital economy network.

Secondly, from the point of view of the degree of proximity to the center, the degree of proximity to the center is to discern the degree of difficulty in generating spatial correlation between the development of the digital economy between the various provinces and regions to generate spatial correlation generated, Jiangsu, Guangdong, Shandong, Zhejiang, Beijing, Shaanxi and other provinces in the forefront, and other provinces and regions are able to generate a strong digital economy link between the provinces and regions, showing a stronger correlation, which is due to the fact that the eastern provinces and regions of the eastern region have a more solid foundation for digital economic development, digitization, Informatization and Intelligent level is relatively high. Heilongjiang, Jilin, Hainan, these provinces are close to the center of the degree is lower, indicating that the digital economic development of other provinces to promote the role of these provinces, the reason is that this is smaller, the geographical location of these provinces is relatively more remote, the economic development is slower, and the surrounding provinces have a better development of the digital economy, which makes the digital economic spatial link between these provinces and other provinces is weaker.

Table 4. Indicators of spatial correlation network centrality of China's digital economy development level in 2021

province	point degree center				proximity to center		intermediation center	
	outdegree	degree	centrality	rank	centrality	rank	centrality	rank
Shanghai	2	14	48.276	8	65.909	8	1.927	7
Yunnan	9	1	31.034	15	59.184	16	0.323	20
Inner Mongolia	7	1	27.568	27	58.000	18	1.001	12
Beijing	4	19	68.966	5	76.316	5	7.630	3
Jilin	6	2	20.690	29	54.717	29	0.018	26
Sichuan	9	8	48.276	8	65.909	8	1.255	10
Tianjin	9	4	31.034	15	61.702	12	0.185	22
Ningxia	13	2	44.828	10	64.444	10	1.122	11
Anhui	4	10	37.931	13	61.702	12	0.410	17
Shandong	8	18	72.414	3	78.378	3	7.554	4
Shanxi	7	4	31.034	15	58.000	18	0.357	19
Guangdong	12	16	75.862	2	80.556	2	11.086	2
Guangxi	6	5	27.586	21	58.000	18	1.758	8
Xinjiang	8	0	27.586	21	58.000	18	0.080	25
Jiangsu	4	27	93.103	1	93.548	1	16.307	1
Jiangxi	8	4	27.586	21	56.863	25	0	27
Hebei	6	7	31.034	15	58.000	18	0.375	18
Henan	11	6	41.397	11	63.043	11	0.786	14
Zhejiang	3	21	72.414	3	78.378	3	7.262	5
Hainan	2	2	6.897	30	46.774	30	0	27
Hubei	10	10	51.724	7	67.442	7	1.639	9
Hunan	8	7	41.397	11	61.702	12	0.991	13
Gansu	9	2	31.034	15	59.184	16	0.107	23
Fujian	7	3	27.586	21	56.863	25	0	27
Guizhou	9	4	31.034	15	58.000	18	0.206	21
Liaoning	8	2	27.586	21	56.863	25	0.714	15
Chongqing	9	5	37.931	13	61.702	12	0.583	16
Shanxi	12	8	58.621	6	70.732	6	2.452	6
Qinghai	8	2	27.586	21	58.000	18	0	27
Heilongjiang	7	2	24.138	28	55.769	28	0.094	24
Average	7.5	7.2	40.805		63.456		2.207	

Finally, according to the results of intermediary centrality measurement, intermediary centrality is an assessment of the control power of each province in the development of digital economy, with Jiangsu, Guangdong, Shandong, Zhejiang and Beijing in the forefront, and the above provinces play an important role as "bridges" in the network, and have a strict control over the flow of the required financial, technological and other resource elements. The total intermediary centrality of these five provinces is 49.839, accounting for more than 75% of the total centrality. Most of these provinces are in the economically developed regions on the eastern coast of China, with higher levels of technological innovation and stricter government regulation of digital economy development, making it easier to absorb digital economy factor resources flowing out of other provinces in order to achieve strong control over other provinces. Jilin, Xinjiang, Qinghai, Jiangxi and Fujian have a lower degree of intermediary centrality, indicating that these provinces are marginalized and controlled.

In general, in the study area, Beijing, Zhejiang, Guangdong, Jiangsu, Shandong and other economically more developed

provinces have outstanding performance in all indicators, and are in an important position in the spatial network of China's digital economy; Shaanxi is the hub connecting the northwest and the central region, and the digital economy is better developed, which makes Shaanxi play an important role in the spatial network of the digital economy, and it has stronger control and dominance over the resource elements required for the digital economy; the northeast and northwest regions are remote and the level of digital economy development is weak, indicating that the ability of digital economy development to obtain resources is weaker and is in a marginalized position in the network. control and dominance; the remote and weak level of digital economy development in the Northeast and Northwest, the network centrality of the provincial regions is generally low, indicating that the ability of digital economy development to access resources is weak, and is in a marginalized position in the network. There are also some provinces such as Fujian, Jiangxi, etc., although the level of development of their own digital economy is relatively good, but due to the large gap with the level of development of the digital economy of the surrounding

provinces, the network centrality of these provinces is low, and they are in a more marginal position in the spatial network of China's digital economy.

(3) Core-edge structural analysis

In order to clearly see the spatial network structure of China's digital economy development level in 2021, according to Ucinet6 software Network/ Core& Periphery/ Categorical on China's digital economy spatial correlation network in 2021 is divided into the core provinces and edge

provinces and drew out the spatial network structure map, as shown in Figure 2, Shanghai, Beijing, Sichuan, Anhui, Shandong, Guangdong, Jiangsu, Henan, Zhejiang, Hubei and Shaanxi are in the core position of the network, and other provinces are in the edge position, and calculated that the network density between these eleven provinces reaches 0.564, and they not only have the advantage of geographic location, but also have relatively good economic development and infrastructure.

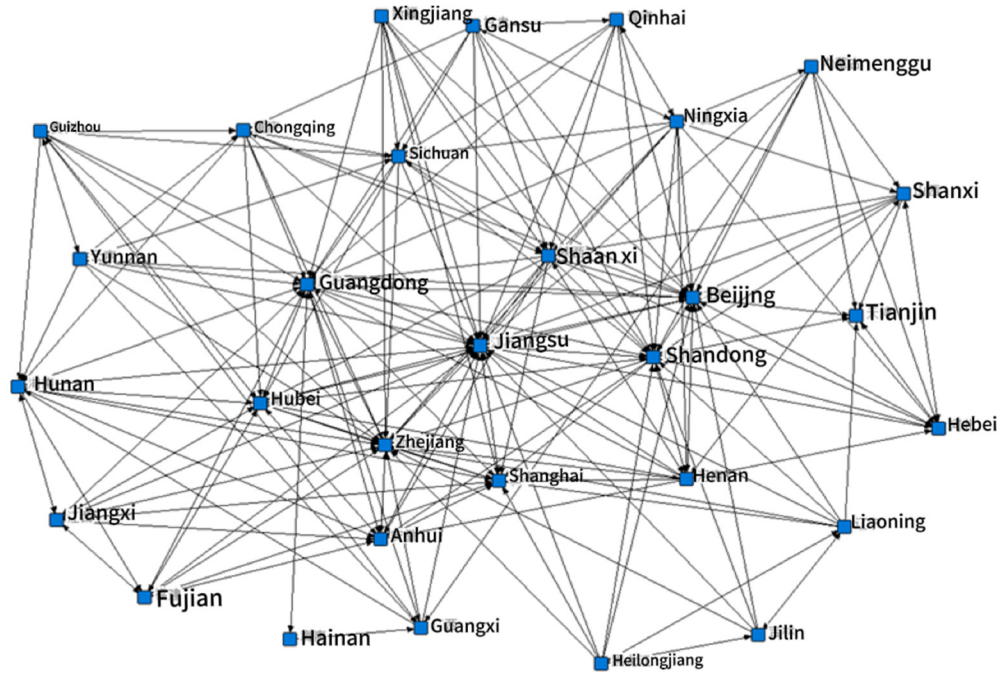


Figure 2. Structure of our digital economy spatial network in 2021

5. Conclusion and Insights

Based on the panel data of 30 provinces in China from 2013 to 2021, the entropy method is used to measure the comprehensive development index of digital economy, and the gravity model and social network analysis are applied to examine the spatial correlation network structure characteristics of digital economy among provinces and regions. The following main conclusions are drawn: (1) the overall digital economy development level of the country and provinces and municipalities is on the rise, but there is a large gap in the level of digital economy development among provinces, and the development level is gradually decreasing from the eastern coastal area to the western inland area of China; (2) the spatial network structure of China's digital economy development level has a better robustness, and the spatial correlation on the whole is strengthened, but the development speed is very Slowly, the hierarchical structure of the spatial network of China's digital economy development level is relatively strict, and different geographic locations and different levels of development of the regions examined are likely to produce spatial interaction effects; (3) There is a gap between the various provinces and regions, forming a "core-edge" distribution structure, Shanghai, Beijing, Sichuan, Anhui, Shandong, Guangdong, Shanghai, Beijing, Sichuan, Anhui, Shandong, Guangdong, Jiangsu, Henan, Zhejiang, Hubei, and Shaanxi are at the core of the network, with significant spatial correlation with other provinces and regions, and strong influence, among which, the regions of Beijing, Jiangsu, Guangzhou, Zhejiang, and

Shandong Province have strong control and structural advantages in the whole network.

The following policy insights are proposed in light of the above conclusions: (1) Accelerate digitalization reforms to narrow the inter-provincial digital gap. The government should accelerate the construction of digital infrastructure in remote areas, increase investment in science and technology and research and development, and continuously improve the digital environment, while following regional advantages and implementing differentiated digital economic policies to fully release digital dividends, and continuously narrow the inter-provincial digital development gap; (2) Promote the development of digital technology and facilitate regional interaction and communication. Continuously promote the development of digital services such as the Internet, big data, digital finance, popularize modern information technology, enhance the ability of residents to use digital technology, and at the same time, relying on digital technology to break through geographic limitations and realize inter-regional interactions and exchanges; (3) Define the development gap between provinces and regions, and effectively bring into play the role of regional radiation and drive. The eastern region should continue to grow and consolidate the digital economy, cultivate the development of new digital industries, and effectively play the role of radiation to drive the development of the digital economy in neighboring regions. The central and western regions should expand the construction of digital infrastructure, optimize the industrial structure, and at the same time strengthen the cooperation and exchange with the digital economy in the eastern region, so

as to stimulate the digital potential to form new growth poles.

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