Statistical Measurement of Spatial and Temporal Differences in Regional Economic Growth in China

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Abstract: This article is devoted to exploring the spatial and temporal equilibrium of China's regional economic growth, constructing a regional economic measurement system based on the requirements of the new normal of economic development, and using factor analysis to statistically measure the economic growth levels of 31 provinces and municipalities in mainland China from 2013-2019. The results show that China's regional economic growth has different characteristics at various levels of economic development, social life, industrial production and resource utilization, among which economic development and social life are the key factors affecting the balance of China's economic growth. In addition, the economic growth level of each province and city has different characteristics in different dimensions, and the overall trend is "decreasing from east to west". Finally, we hope to reveal the development trend and spatial differences of China's regional economic growth under the new normal through the statistical measurement of various provinces and cities and various indicators, and to contribute Chinese solutions and experiences to achieve sustainable and balanced economic development.

Keywords: Regional Economy, Factor Analysis, Economic Growth, Statistical Measures.

1 INTRODUCTION

Since the reform and opening up of China, the continuous optimization of China's economic structure has enabled the economy to maintain a long-term trend of steady growth, and in 2010, China's average annual GDP growth rate surpassed that of Japan to become the world's second largest economy after the United States. However, the imbalance between China's regional economic development and the incompatibility between economic growth and resource conservation have become two major potential constraints to the balanced growth of China's economy. With the development of China's economy and society, excessive resource consumption and negative economic growth have become inevitable core problems. The increasing dependence of economic growth on investment demand, the inefficiency of input and output of various factors within the economy, and the unreasonable allocation of resources are a series of economic risks that will hinder the coordinated development of the regional economy.

As economic growth is the key issue of regional economics research, there should be scientific theoretical guidance to achieve high-quality economic growth and coordinated economic development among regions in China accordingly, so as to better reveal the essential requirements and social laws of high-quality economic development. Based on the requirement

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of high-quality and coordinated regional economic development, narrowing the differences in economic development among regions and dealing with the relationship between economic growth and ecological sustainability have become the top priority nowadays. How to better measure the level of regional economic development in China and analyze the factors influencing the differences in economic growth is the focus of this paper.

The report of the 19th Party Congress emphasizes that China's economy has transformed from high-speed growth to high-quality development, which means that high-quality economic growth model has become the core lever of China's economic development in the new era, and also indicates that China's economic construction in the future should adhere to high-quality and high-standard as the measure of development. However, at this stage, the research on the economic growth status of each region in China is still mainly at the level of evaluation of high-quality economic development, and the research on the influencing factors of regional economic differentiation is also slightly insufficient.

2 LITERATURE REVIEW

China's high-quality economic development and economic synergistic growth fit the inherent requirements of the new development concept. From the perspective of economics, high-quality economic development is committed to meeting the people's growing value and spiritual pursuit of a better life dimension, reflecting the essential characteristics of economic development; while economic synergistic growth reflects the docking of products and services based on the perspective of supply-side structural reform to enhance the intrinsic value of China's economic policies. value. The organic combination of the two is the inherent embodiment of achieving common prosperity and synergistic economic growth, which is in line with the inherent requirements of the new development concept. From the current research literature, academic research on the issue of high-quality development and economic growth differentials in China's economy is still in the exploratory stage.

Yachen Shen and Rui Wu(2022) constructed a regional digital economy development measurement index system and used the entropy value method to measure the level of regional digital economy development from two dimensions of industrial digitization and digital industry, and found that investment efforts, government regulation mechanism, transportation infrastructure construction and education level are the significant reasons for the differences between the digital economy and the regional economic quality development. Ju Pan and Dan Yang(2019) used quantile regression to confirm the association between the differences in capital, human, technology and institutional economic factors and the regional economic development gap, and found that the differences in capital and human factor inputs are the reasons for the significant differences in regional economic development in China. Ying Li(2020) illustrated the differences in economic growth levels among Chinese regions from the perspective of geographic economics, and analyzed the agglomeration effect and spatial heterogeneity of each economic factor. Min Wei and Shuhao Li(2018) confirmed the existence of a close correlation between high-quality economic development and economic growth, and analyzed the changes in spatial and temporal differences of regional economic development from the perspective of economic growth, further analyzing the coordination of China's economic development level and economic policies, responding to the conceptual requirements of China's economic development in the new era, and also summarizing and sublimating the theory of economic growth measurement. Baoping Ren et al.(2015) indicate that there is some correlation between the overall and regional economies in China, and there are temporal and spatial differences in the quality of economic growth between the overall and regional economies. Jie Wei et al.(2021) conducted a deeper investigation and consideration on the issue of regional economic growth efficiency and development imbalance. Chunhui Gan et al.(2011) constructed the economic growth index from four dimensions: economic structure, growth status, changes in economic growth welfare and resource sustainability, and then measured the regional economic development. Kun Li(2019) measured China's economic development from the perspectives of economic growth dynamics, structural differences, social welfare and resource environment. Wei Wang(2020) selected the indicators of the economy of scale, industrial structure and ecological coordination to construct the measurement system, and used factor analysis and principal component analysis to measure the regional economic development level. Ying Xu et al.(2004) constructed the system of high-quality economic development from three dimensions, including social economy, industrial sector and market factors, and focused on the differences in economic development among Chinese regions. The measurement of regional economic development level differences in the literature is also the research direction of this paper.

In general, the research on the development of China's regional economies and the differences in economic growth should be focused on. Therefore, this paper draws on the measurement ideas of the existing literature and uses factor analysis to study and analyze the differences in regional economic development and economic growth in China and the influencing factors, and determines the association between the indicators of each economic factor and the differences in economic growth in the context of the regional economy through the weight values of indicators, which enriches the research theory and practical reference on the measurement of the regional economy.

3 DATA SELECTION AND THEORETICAL MODEL

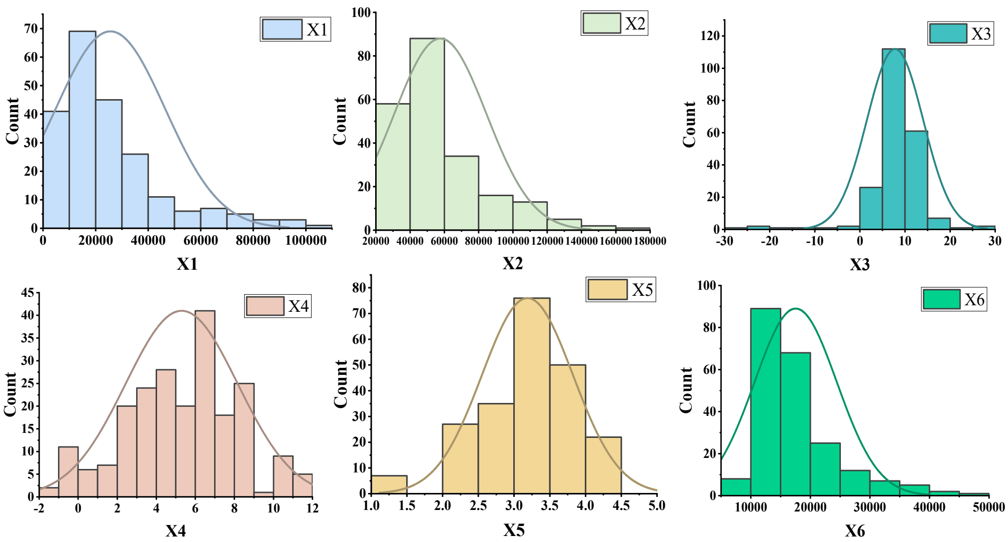
3.1 Data Selection

Due to the influence of many comprehensive factors, regional differences in China's economic growth appear. Therefore, regional economic evaluation indicators should be selected from multiple perspectives, and an economic measurement and evaluation system should be constructed to analyze the reasons for the differentiation of economic growth among regions by measuring the degree of influence of their indicators, and to identify the important influencing factors. To ensure the scientificity and rigor of the data, this paper reviews the relevant data information of the China Statistical Yearbook and Environmental Statistical Yearbook, and on the basis of the research results of Liu Guobin, Song Jinze, Ren Baoping and other scholars, selects the representative economic development indicators in 31 provinces and cities in inland China from 2013 to 2019, and finally constructs the indicator evaluation system based on the principles of representativeness, comprehensiveness and comparability as well as China's philosophy about regional economic synergistic high-quality development under the new normal, the complex regional economic synergistic development and endogenous growth concept is decomposed into four major dimensions of economic development, social life, industrial production and resource utilization, and further subdivided into 14 indicators, as shown in Table 1.

Table 1: Economic development measurement indicators

System level	Indicator Level	Code
Economic Development	GDP	X_1
	GDP per capita	X_2
	GDP Growth Rate	X_3
Social life	Natural Population Growth Rate	X_4
	Urban Registered Unemployment Rate	X_5
	Per capita consumption expenditure of urban households	X_6
Industrial Production	Chemical Oxygen Demand Emission	X_7
	Industrial Dust Emission	X_8
	Industrial wastewater	X_9
	Industrial fixed waste	X_{10}
	Industrial sulfur dioxide emissions	X_{11}
Resource Utilization	Energy consumption per unit GDP	X_{12}
	Water consumption per unit GDP	X_{13}
	Fixed asset investment per unit of GDP	X_{14}

The statistical distribution of the number of indicators is shown in Figure 1 below.



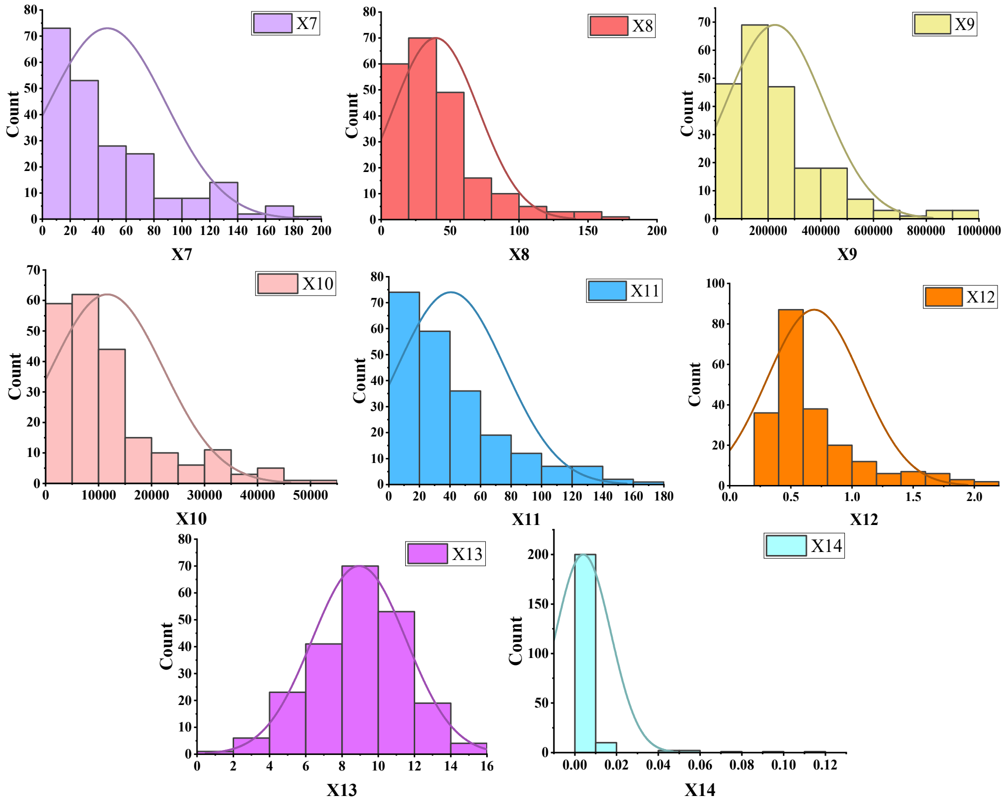


Figure 1: Statistical results of the number of indicators

3.2 Measurement Models and Methods

Thurstone first introduced the concept of factor analysis method in 1931, which was initially used for simple statistical analysis of data, but with the in-depth exploration and development of the discipline of computational science, factor analysis has been widely used in various statistical disciplines. Factor analysis aims at describing statistics and interpreting the components of the original observations by summing linear and special factors with a minimum number of unpredictable factors. The greatest advantage of the factor analysis method is the practicality of its dimensionality reduction idea, which can convert multiple indicators into a small number of uncorrelated indicators, thus transforming a complex analysis into a simple multivariate analysis method, allowing the data to reflect the relational nature between them by itself. Therefore, this paper adopts the factor analysis method to measure the economic development level of each region in China, so as to ensure the rationality and scientificity of the empirical quantitative analysis as much as possible from the root.

Let $X = (x_1, x_2, \cdots, x_p)^T$ be the observable variables of the economic development level measure in this paper, and due to the different unit and dimensionless process among the variables, the standardized variables $\widetilde{x_i}$ are obtained by using the polarization method of equation (1), $K = (k_1, k_2, \cdots, k_q)^T$ as factor vector, $M = T_{ij}(i = 1,2, \cdots, p; j = 1,2, \cdots, q)$ is the factor loading matrix, and $\delta = (\delta_1, \delta_2, \cdots, \delta_p)^T$ is the special factor. The factor analysis model equation (2) and equation (3) are obtained as follows.

$$\widetilde{x_i} = \frac{X - X_{min}}{X_{max} - X_{min}} \tag{1}$$

$$\begin{cases} \widetilde{x_1} = T_{11}k_1 + T_{12}k_2 + \cdots + T_{1q}k_q + \delta_1 \\ \widetilde{x_2} = T_{21}k_2 + T_{22}k_2 + \cdots + T_{2q}k_q + \delta_2 \\ \vdots \\ \widetilde{x_p} = T_{p1}k_1 + T_{p2}k_2 + \cdots + T_{pq}k_q + \delta_p \end{cases} \tag{2}$$

$$X = KM + \delta = KT_{ij} + \delta \tag{3}$$

The sum of the squared terms of the elements in the ith row of the loading matrix M is denoted as $\sum T_i^2, (i = 1,2, \cdots, p)$, then the co-dependence of the indicator variable X is the co-dependence of the common factor K on the variable X, which can reflect the dependence of all the co-dependent factors on the indicator variable X. The larger the value of $\sum T_i^2$, the greater the dependence of the ith indicator on each of the common factors K, and vice versa. and vice versa. Similarly, the sum of the squared terms of the elements of the jth column in the loading matrix M is denoted as $\sum T_j^2, (j = 1,2, \cdots, q)$. $\sum T_j^2$ indicates the variance contribution of the public factor K to the variable X. The larger the value, the higher the contribution of the jth indicator to each public factor K.

After the dependence and contribution calculation of the factor model, the factor loadings need to be rotated.

Let U be an orthogonal matrix, and the rotated factor loading matrix $L = l_{ij}(i = 1,2, \cdots, p; j = 1,2, \cdots, q)$ is obtained by equation (4). Further, a new factor analysis model is constructed as shown in equations (5) and (6) below.

$$L = MU \tag{4}$$

$$\begin{cases} \widetilde{x_1} = l_{11}k_1 + l_{12}k_2 + \cdots + l_{1q}k_q + \delta_1 \\ \widetilde{x_2} = l_{21}k_2 + l_{22}k_2 + \cdots + l_{2q}k_q + \delta_2 \\ \vdots \\ \widetilde{x_p} = l_{p1}k_1 + l_{p2}k_2 + \cdots + l_{pq}k_q + \delta_p \end{cases} \tag{5}$$

$$X = KMU + \delta = Kl_{ij} + \delta \tag{6}$$

Finally, each factor is expressed as a linear combination equation (7) based on the original variables, from which the composite score of each factor is calculated.

$$\hat{E}_j = l_{ij}\tilde{x}_1 + l_{ij}\tilde{x}_2 + \cdots + l_{ij}\tilde{x}_p \tag{7}$$

4 EMPIRICAL ANALYSIS

4.1 Descriptive Statistics

This paper refers to the relevant statistical data of the China Statistical Yearbook and Environmental Statistical Yearbook, selects the economic indicators of 31 provinces and municipalities in China from 2013 to 2019, and constructs the measurement and evaluation system. In addition, for the consideration of data authenticity, validity and predictability, the article standardizes the selected data, and some missing data are complemented by Lagrangian interpolation method, and finally 217 valid samples are obtained, corresponding to the principle method of interpolation as follows.

By constructing a plane containing n points, we can obtain a polynomial equation that passes through n points in the plane and contains $n-1$ terms to the nth power.

$$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \cdots + \beta_{n-1} x^{n-1} \tag{8}$$

The coordinates of these n points in the plane $(x_1, y_1), (x_2, y_2) \cdots, (x_n, y_n)$ are then substituted into the polynomial (8) to obtain a system of n equations.

$$\begin{cases} y_1 = \beta_0 + \beta_1 x_1 + \beta_2 x_1^2 + \cdots + \beta_{n-1} x_1^{n-1} \\ y_2 = \beta_0 + \beta_1 x_2 + \beta_2 x_2^2 + \cdots + \beta_{n-1} x_2^{n-1} \\ \vdots \\ y_n = \beta_0 + \beta_1 x_n + \beta_2 x_n^2 + \cdots + \beta_{n-1} x_n^{n-1} \end{cases} \tag{9}$$

which leads to the solution of the Lagrangian system of equations.

$$\begin{aligned} L(x_i) = y_1 \frac{(x-x_2)(x-x_3)\cdots(x-x_n)}{(x_1-x_2)(x_1-x_3)\cdots(x_1-x_n)} \\ + y_2 \frac{(x-x_1)(x-x_3)\cdots(x-x_n)}{(x_2-x_1)(x_2-x_3)\cdots(x_2-x_n)} + \cdots \\ + y_n \frac{(x-x_1)(x-x_2)\cdots(x-x_{n-1})}{(x_n-x_1)(x_n-x_2)\cdots(x_n-x_{n-1})} \\ = \sum_{i=0}^{n} y_i \prod_{j=0, j\neq i}^{n} \frac{x-x_j}{x_i-x_j} \end{aligned} \tag{10}$$

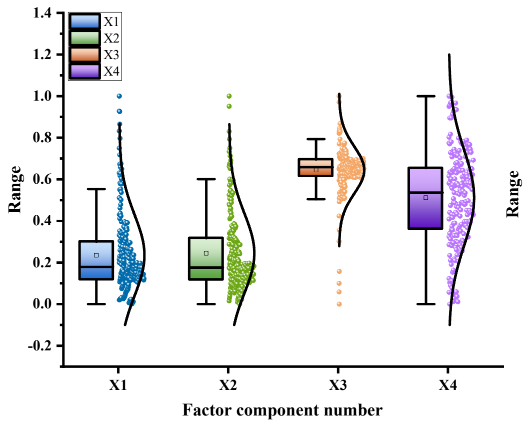
Based on equation (10) above, the approximate value $L(x)$ of the missing value is obtained by substituting the point x corresponding to the missing function value into the interpolation polynomial.

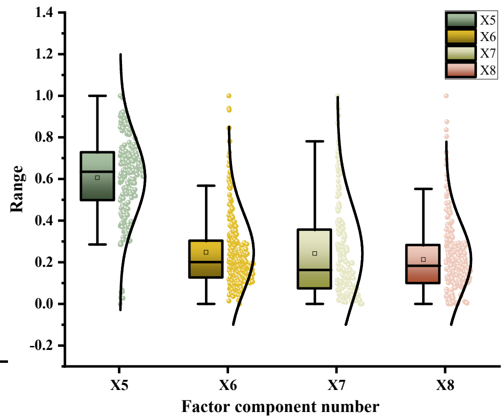
The results of descriptive statistics were further analyzed after interpolation of the data, as shown in Table 2 below.

Table 2: Descriptive statistics

Variables	Obs	Max	Min	Average	Std	Median	Variance	Kurtosis	Skewness	CV
X_1	217	1	0	0.235	0.194	0.179	0.038	2.649	1.579	0.8273
X_2	217	1	0	0.245	0.191	0.176	0.036	1.926	1.462	0.7802
X_3	217	1	0	0.645	0.113	0.658	0.013	11.82	-2.303	0.1747
X_4	217	1	0	0.511	0.228	0.536	0.052	-0.348	-0.17	0.4452
X_5	217	1	0	0.606	0.195	0.635	0.038	0.61	-0.651	0.3222
X_6	217	1	0	0.248	0.185	0.201	0.034	3.234	1.718	0.7481
X_7	217	1	0	0.242	0.231	0.163	0.053	1.021	1.289	0.9545
X_8	217	1	0	0.213	0.174	0.183	0.03	3.35	1.55	0.8168
X_9	217	1	0	0.237	0.197	0.198	0.039	3.25	1.637	0.8293
X_{10}	217	1	0	0.217	0.204	0.158	0.042	2.003	1.487	0.9407
X_{11}	217	1	0	0.246	0.215	0.174	0.046	1.156	1.225	0.8728
X_{12}	217	1	0	0.263	0.21	0.195	0.044	2.095	1.586	0.7990
X_{13}	217	1	0	0.515	0.19	0.517	0.036	-0.087	-0.146	0.3688
X_{14}	217	1	0	0.034	0.11	0.006	0.012	42.196	6.152	3.2534

As can be seen from Table 2, the mean value of GDP is 2,564.1575 billion yuan and the GDP per capita is 57,652.806 yuan, indicating that China's economic development in this period showed a good trend and adapted to the requirements of high-quality sustainable economic development. However, the standard deviations corresponding to both indicators are large, which reflects that while China's economy continues to grow, there are still large differences in economic development among regions. In addition, the average GDP growth rate is 7.796%, which is greater than 3%, indicating that China's economic development in this period has a certain scale and a positive development trend, and the living standard of urban and rural residents has been improved.





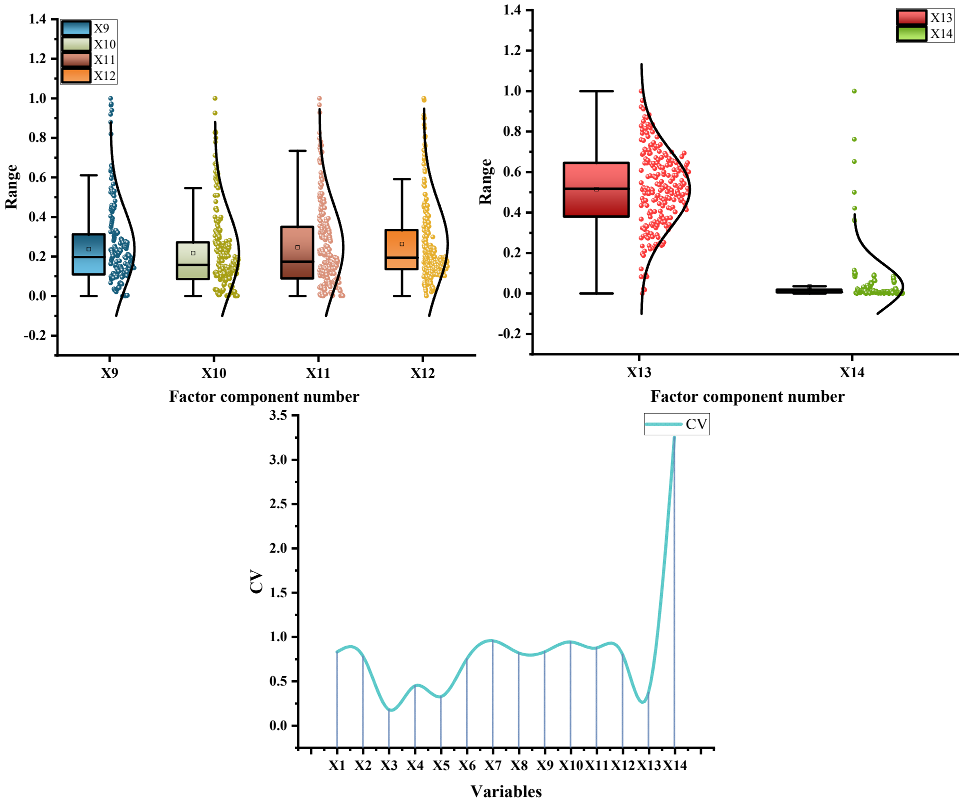


Figure 2: Data distribution and coefficient of variation characteristics of the factor component numbers

As can be seen from the results of Figure 2, only the data corresponding to GDP growth rate (X_3), natural population growth rate (X_4), urban registered unemployment rate (X_5) and water consumption per unit of GDP (X_{13}) as a whole approximately obey a normal distribution, while the rest of the indicators show skewed distribution. It indicates that these four data indicators have good symmetry and stability. It indicates that the GDP level and the natural population growth rate of Chinese provinces and cities maintain a relatively stable growth rate during the period 2013-2019. In addition, the data distribution of the urban registered unemployment rate in each province and city between these seven years is more concentrated than the rest of the indicators, indicating that the urban unemployment rate in each region of China has maintained a stable trend during this period. Similarly, the data distribution of the unit GDP water consumption indicator also indicates that the water consumption of the regional GDP in each province and city of China is basically stable in general. The distribution of the coefficient of variation shows that the X_{14} indicators are more discrete in their data distribution, which also indicates that there are significant spatial and temporal differences in the amount of fixed asset investment in China's regional GDP.

4.2 KMO Test and Bartlett's Sphericity Test

The KMO test is based on the principal component analysis to select the factors with representative significance and significant correlation from the original many factors, and compare them systematically with the original variables to analyze the correlation degree coefficient and bias correlation coefficient between them. If the KMO value tends to 1, it means that the correlation between the factor and the original variable is strong, and vice versa. The selection of representative factors is based on whether the KMO test value is greater than 0.7. If the test value is greater than 0.7, it means that the selected factors are more suitable for the measurement model of this paper. The expression of the KMO test is constructed as follows.

$$KMO = \frac{\sum\sum_{i\neq j} r_{ij}^2}{\sum\sum_{i\neq j} r_{ij}^2 + \sum\sum_{i\neq j} r_{ij.1,2,\cdots,k}^2} \tag{11}$$

Bartlett's spherical test presupposes the construction of the correlation coefficient matrix of the factors, and specifies H_0: the correlation coefficient matrix is a unit array as the original hypothesis condition. Further based on the determinant of the correlation coefficient matrix to calculate its statistics, after testing if the Bartlett's approximate chi-square value is large and the corresponding central value of the probability distribution is below the significant level, then in principle H_0 is rejected and there is an association between the original variables and the factors, which can be used for factor analysis. Conversely, H_0 cannot be rejected.

The Kaiser test principle is used to determine whether there is a common factor among the variable indicators, and the limits of the KMO values are also judged to analyze the correlation between the variable indicators. The test results are shown in Table 3.

Table 3: KMO & Bartlett's test

Test Category	Range of values	Factor adaptation	Kaiser-Meyer-Olkin	0.805
KMO	>0.9	Very suitable		
	0.8~0.9	Very suitable	Bartlett's approximate cardinality	2350.713
	0.7~0.8	Suitable		
	0.6~0.7	Barely suitable	df	91.000
	0.5~0.6	Not very suitable		
	<0.5	Not suitable	P-value	0.000***

Based on the requirement of the adequacy of the Kaiser-Meyer-Olkin sample, the numerical magnitude of the correlation coefficient and the bias correlation coefficient of the two factor variables need to be compared, which in turn leads to an important measure of the strength of the correlation between the representative factor and the original variable. After testing, the KMO value of this paper's model is $0.805\epsilon(0.8,0.9)$; the Bartlett's approximate chi-square value is 2350.713, which is a large value, and the test significance level result is less than 0.05, and the original hypothesis is rejected in principle. It indicates that the data in this paper are suitable for the factor analysis model.

4.3 Principal Component Analysis

The principal component analysis is mainly used for the compression and interpretation of factor information and the amplification of principal component information of the original data. Its analysis mainly includes 3 elements, namely, characteristic root, variance contribution rate and cumulative contribution rate. The explanatory power of the principal components is judged by the characteristic root index, if the characteristic root is less than 1, it means that the explanatory power of the selected principal component factors is slightly lower than that of the original variables, and vice versa; the variance contribution rate has a positive correlation with the characteristic root, the higher the variance contribution rate, the stronger the ability to extract explanations for the information; the cumulative contribution rate indicates the amount of information extracted by the first n principal component factors, which can also be interpreted as the principal component The cumulative contribution rate indicates the cumulative amount of information extracted by the first n principal component factors, which can also be interpreted as the combined contribution influence of the principal component factors to the overall sample. It is usually considered that the total contribution of the first n principal component factors exceeds 80%, which can indicate that these first n principal component factors can explain the overall information of the sample.

Table 4: Principal component feature roots

Variables	Initial Eigenvalue			Extraction of the sum of squares of loads			Sum of squared rotating loads		
	Total	Percentage of variance	Accumulation	Total	Percentage of variance	Accumulation	Total	Percentage of variance	Accumulation
X_1	4.136	29.544	29.544	4.136	29.544	29.544	2.826	20.183	20.183
X_2	3.015	21.534	51.079	3.015	21.534	51.079	2.603	18.594	38.777
X_3	1.844	13.175	64.253	1.844	13.175	64.253	2.383	17.023	55.800
X_4	1.198	8.559	72.813	1.198	8.559	72.813	1.705	12.177	67.978
X_5	1.018	7.273	80.086	1.018	7.273	80.086	1.695	12.108	80.086
X_6	0.741	5.290	85.376						
X_7	0.610	4.361	89.737						
X_8	0.513	3.661	93.398						
X_9	0.314	2.243	95.641						
X_{10}	0.224	1.599	97.241						
X_{11}	0.175	1.253	98.494						
X_{12}	0.128	0.912	99.406						
X_{13}	0.060	0.431	99.837						
X_{14}	0.023	0.163	100.000						

As can be seen from Table 4, the first five principal component factors correspond to eigenroots greater than 1, and the cumulative variance contribution rate is 80.086% > 80%, indicating that the first five indicators in the data selected for this paper have strong explanatory power of information for the overall sample, and are also the main factors affecting the differences in regional economic growth, namely: GDP, GDP per capita, GDP growth rate, natural population growth rate and urban registered unemployment rate. The characteristic root fragmentation plots corresponding to the 14 indicators tested are as follows.

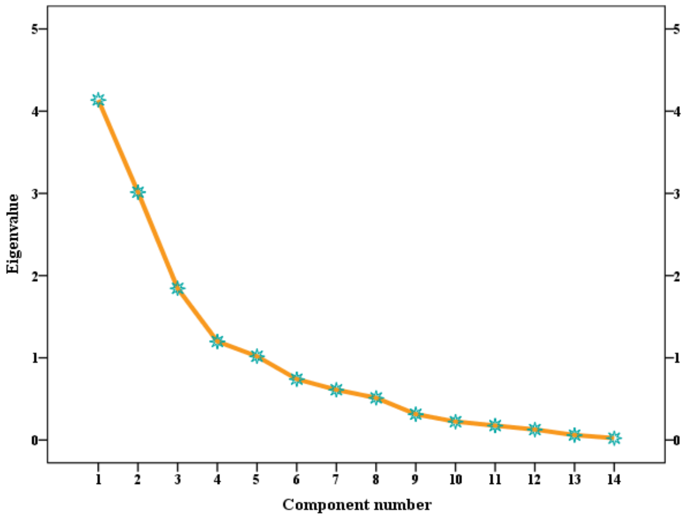


Figure 3: Gravel map

As can be seen in Figure 3, the eigenvalue curves within the interval of the first five variables are steeper, indicating that the first five factor variables explain the research problem of this paper to a higher degree; when the number of variable factors reaches six, their eigenvalue curves tend to level off, so the first five variables are used as the extracted factors. Further, principal component analysis was applied to extract the variable factors to construct the factor loading matrix, and the quantitative relationship between each factor and the original variables was analyzed by observing the coefficients of the matrix. The rotated component matrix was obtained after quantifying and eliminating the unreasonable variables in the matrix, so that the correspondence between all data variables and the selected factors met the expected effect. The results are shown in Tables 5 and 6.

Table 5: Component matrix

Variables	Component Factors				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
X_1	-0.046	0.913	0.166	-0.029	-0.231
X_2	-0.670	0.566	-0.312	0.001	-0.013
X_3	-0.164	-0.004	0.646	0.136	-0.246
X_4	0.045	-0.336	0.673	0.328	-0.236
X_5	0.496	-0.064	-0.372	-0.581	-0.146
X_6	-0.764	0.446	-0.309	0.001	0.028
X_7	0.605	0.564	0.280	-0.086	0.277
X_8	0.749	0.330	-0.274	0.313	-0.095
X_9	0.156	0.875	0.315	-0.113	-0.050
X_{10}	0.579	0.240	-0.382	0.365	-0.388
X_{11}	0.794	0.324	-0.003	0.220	0.149
X_{12}	0.542	-0.395	-0.355	0.298	0.042
X_{13}	0.609	-0.011	0.282	-0.250	0.512
X_{14}	-0.496	0.187	-0.108	0.532	0.549

Table 6: Component matrix after rotation

Variables	Component Factors					Common factor variance
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
X_1_s	0.940	0.160	-0.077	0.046	-0.002	0.917
X_2_s	0.503	-0.202	-0.529	0.380	0.384	0.866
X_3_s	0.201	-0.185	-0.040	0.017	-0.668	0.523
X_4_s	-0.154	-0.024	0.061	0.001	-0.838	0.731
X_5_s	-0.074	0.149	0.177	-0.694	0.454	0.747
X_6_s	0.394	-0.302	-0.566	0.419	0.370	0.879
X_7_s	0.511	0.294	0.704	-0.037	0.030	0.846
X_8_s	0.129	0.862	0.259	-0.085	0.134	0.852
X_9_s	0.910	0.133	0.238	0.002	-0.034	0.904
X_{10}_s	0.072	0.881	-0.092	-0.166	0.074	0.823
X_{11}_s	0.165	0.674	0.567	-0.027	0.037	0.805
X_{12}_s	-0.569	0.550	0.164	-0.074	0.094	0.667
X_{13}_s	-0.033	0.011	0.869	-0.127	0.048	0.776
X_{14}_s	0.000	-0.097	-0.086	0.918	0.132	0.876

From the rotated factor component matrix in Table 6 and the rotated factor loadings heat map in Figure 4, it can be seen that factor 1 has high loadings on variables X_1_s, X_2_s and X_9_s, indicating that factor 1 is an economic factor; similarly, since factor 2 has high loadings on variables X_8_s and X_{10}_s, factor 2 is defined as an industrial factor; factor 3 has high loading on variable X_{13}_s, defined as the energy consumption factor; factor 4 has a higher loading on variable X_{14}_s, defined as the investment factor; and factor 5 has a higher loading on variables X_5_s and X_6_s, defined as the social factor.

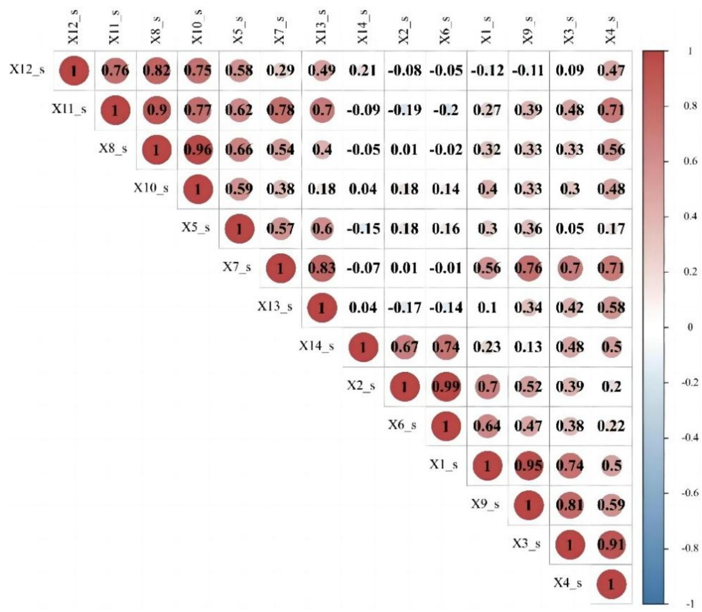


Figure 4: Heat map of rotational factor loadings

4.4 Overall Score Assessment

In order to further investigate the factors affecting the balanced development of China's regional economies and causing differences in economic growth, this paper uses factor analysis to calculate the combined score coefficients of each factor, as shown in Table 7.

Table 7: Corresponding feature vectors of principal components

Component Matrix					
Variables	Main component 1	Main component 2	Main component 3	Main component 4	Main component 5
	k_1	k_2	k_3	k_4	k_5
X_1	0.227	0.053	-0.042	0.038	-0.002
X_2	0.122	-0.067	-0.287	0.317	0.377
X_3	0.049	-0.061	-0.022	0.014	-0.656
X_4	-0.037	-0.008	0.033	0.001	-0.823
X_5	-0.018	0.05	0.096	-0.579	0.446
X_6	0.095	-0.1	-0.307	0.35	0.364
X_7	0.124	0.098	0.382	-0.031	0.029
X_8	0.031	0.286	0.14	-0.071	0.132
X_9	0.22	0.044	0.129	0.002	-0.034
X_{10}	0.018	0.292	-0.05	-0.139	0.073
X_{11}	0.04	0.224	0.308	-0.022	0.037
X_{12}	-0.137	0.182	0.089	-0.062	0.092
X_{13}	-0.008	0.004	0.471	-0.106	0.047
X_{14}	0.0	-0.032	-0.047	0.766	0.13

Combining the total variance of the original variables explained in Table 5 and the corresponding eigenvectors of the principal components in Table 7, the combined score function of each factor can be constructed.

- $E_1 = 0.227X_1 + 0.122X_2 + 0.049X_3 - 0.037X_4 - 0.018X_5 + 0.095X_6 + 0.124X_7 + 0.031X_8 + 0.22X_9 + 0.018X_{10} + 0.04X_{11} - 0.137X_{12} - 0.008X_{13} + 0.0X_{14}$.
- $E_2 = 0.053X_1 - 0.067X_2 - 0.061X_3 - 0.008X_4 + 0.05X_5 - 0.1X_6 + 0.098X_7 + 0.286X_8 + 0.044X_9 + 0.292X_{10} + 0.224X_{11} + 0.182X_{12} + 0.004X_{13} - 0.032X_{14}$.
- $E_3 = -0.042X_1 - 0.287X_2 - 0.022X_3 + 0.033X_4 + 0.096X_5 - 0.307X_6 + 0.382X_7 + 0.14X_8 + 0.129X_9 - 0.05X_{10} + 0.308X_{11} + 0.089X_{12} + 0.471X_{13} - 0.047X_{14}$.
- $E_4 = 0.038X_1 + 0.317X_2 + 0.014X_3 + 0.001X_4 - 0.579X_5 + 0.35X_6 - 0.031X_7 -$

$0.071X_8 + 0.002X_9 - 0.139X_{10} - 0.022X_{11} - 0.062X_{12} - 0.106X_{13} + 0.766X_{14}$.

- $E_5 = -0.002X_1 + 0.377X_2 - 0.656X_3 - 0.823X_4 + 0.446X_5 + 0.364X_6 + 0.029X_7 + 0.132X_8 - 0.034X_9 + 0.073X_{10} + 0.037X_{11} + 0.092X_{12} + 0.047X_{13} + 0.13X_{14}$.

Finally, the composite factor score function is derived from Equation (7).

$$E = \frac{0.202}{0.801} \times E_1 + \frac{0.186}{0.801} \times E_2 + \frac{0.17}{0.801} \times E_3 + \frac{0.122}{0.801} \times E_4 + \frac{0.121}{0.801} \times E_5 \quad (12)$$

Finally, the comprehensive economic development ranking of each province and city is calculated based on the comprehensive factor score function (12) formula, as shown in Table 8.

Table 8: Overall score

Province	E_1	E_2	E_3	E_4	E_5	Overall Score(E)	Rank
Guangdong	2.735	-0.233	0.863	0.555	-0.812	0.78	1
Shandong	1.526	1.545	0.021	-0.006	-0.384	0.689	2
Jiangsu	2.234	0.301	-0.353	-0.083	0.342	0.597	3
Liaoning	-0.045	1.06	0.176	0.086	1.793	0.556	4
Hebei	0.073	2.349	-0.303	-0.211	-0.042	0.461	5
Beijing	-0.057	-0.653	-0.809	4.724	0.432	0.446	6
Henan	0.744	0.409	0.583	-0.147	-0.505	0.307	7
Inner Mongolia	-0.574	2.019	-0.977	-0.064	0.972	0.254	8
Shanxi	-0.962	2.353	-0.43	0.001	0.068	0.223	9
Sichuan	0.553	-0.183	0.649	-0.765	0.296	0.163	10
Zhejiang	1.247	-0.614	-0.154	0.121	0.026	0.161	11
Heilongjiang	-0.494	-0.289	0.739	-0.814	1.919	0.132	12
Hunan	0.457	-0.482	0.613	-0.698	0.058	0.036	13
Hubei	0.477	-0.22	0.136	0.02	-0.444	0.034	14
Xinjiang	-1.21	0.932	0.338	0.957	-0.926	-0.011	15
Anhui	0.182	-0.037	0.299	-0.242	-0.799	-0.057	16
Jilin	-0.538	-0.787	0.453	-0.42	1.452	-0.067	17
Guangxi	-0.314	-0.498	0.875	0.08	-0.705	-0.103	18
Shanghai	0.686	-1.293	-1.08	0.052	1.56	-0.113	19
Jiangxi	-0.113	-0.287	0.492	-0.343	-0.548	-0.126	20
Shaanxi	-0.204	0.001	-0.181	-0.383	0.016	-0.145	21
Yunan	-0.391	0.01	0.432	-0.621	-0.531	-0.179	22
Fujian	0.528	-0.556	-0.382	-0.593	-0.29	-0.211	23
Chongqing	-0.166	-0.996	0.293	-0.263	0.202	-0.22	24

Guizhou	-0.699	-0.044	0.383	-0.208	-0.759	-0.251	25
Gansu	-1.187	-0.032	0.196	0.289	-0.47	-0.292	26
Tianjin	-0.113	-1.025	-1.161	-0.291	1.623	-0.312	27
Ningxia	-1.708	-0.014	0.192	-0.33	0.055	-0.435	28
Hainan	-0.89	-1.232	0.168	0.25	-1.034	-0.593	29
Qinghai	-0.894	-0.714	-0.811	-0.312	-0.766	-0.727	30
Tibet	-0.882	-0.789	-1.259	-0.343	-1.799	-0.997	31

The economic development scores of each province and city are calculated and ranked by the regional economic composite factor score function. The results show that: in component E_1, Guangdong, Jiangsu and Shandong provinces rank relatively high, indicating that these regions have a high contribution to China's economic development and help to improve China's economic development; in component E_2, Shanxi, Hebei and Inner Mongolia provinces have the largest industrial contribution value, indicating that these regions mainly focus on industrial development and are typical industrial-driven provinces; in component E_3, Tibet, Tianjin, and Shanghai have the largest energy consumption share, indicating that these provinces and cities mainly focus on energy as the driving force of economic development and are typical energy-driven provinces and cities; in component E_4, Beijing has a larger share of the score than other provinces and cities, which reflects that Beijing has a strong foreign investment attractiveness and its private investment has become the main force driving China's investment growth; in component E_5, the provinces such as Heilongjiang and Liaoning have higher scores for the social factor, indicating that these provinces have a positive employment trend, strong livelihood protection, and high overall consumption levels of residents.

4.5 Analysis of Spatial and Temporal Differences and the Chinese Experience

4.5.1 Statistical Analysis of Spatial and Temporal Differences

Considering the existence of negative values of the composite score index, we add 1 to the corresponding composite score values of each province and city to make all values positive, and also plot the composite score visualization of 31 provinces and cities in mainland China to better analyze the spatial differences of China's regional economic growth during 2013-2019.

Combined with the calculation results of the composite factor score function, it can be seen that the top five provinces in the composite score ranking of the principal component factors are Guangdong, Shandong, Jiangsu, Liaoning, and Hebei, indicating that these five provinces have a high level of comprehensive economic development; while Hainan, Qinghai, and Tibet rank relatively low, indicating a low level of comprehensive economic development. Looking at the visualization of the overall composite score index distribution of Chinese provinces and cities in Figure 5, it can be found that the regional economic growth level of China generally shows a "three-step" decreasing trend from east to west during the period of 2013-2019. The eastern coastal region, mainly Guangdong, Shandong and Jiangsu, occupies most of the space for China's export-oriented economic development due to its superior geographical location, and has broad market prospects for technology, capital and foreign investment. In addition, most of the eastern regions of China are also important hubs connecting China's inland industries to the markets of foreign companies. Especially during the transition period from the 12th Five-Year Plan to the 13th Five-Year Plan, the government's policy support for the eastern coastal areas has increased, which to a certain extent has contributed to the high-quality development of China's coastal economic zone. The central region occupies the majority of the Yangtze River Economic Belt in China, which enables economic and technological exchanges with the outside world to a certain extent, and many provinces and cities in the central region are the gathering places of China's high-tech industries, which have strong industrial innovation and synergy capabilities, thus contributing more to the overall economic development than the western region. Due to its remote location, the western region of China largely restricts the external exchange and development of the regional economy, which also leads to the overall economic competitiveness of the western region being lower than that of the central and eastern regions.

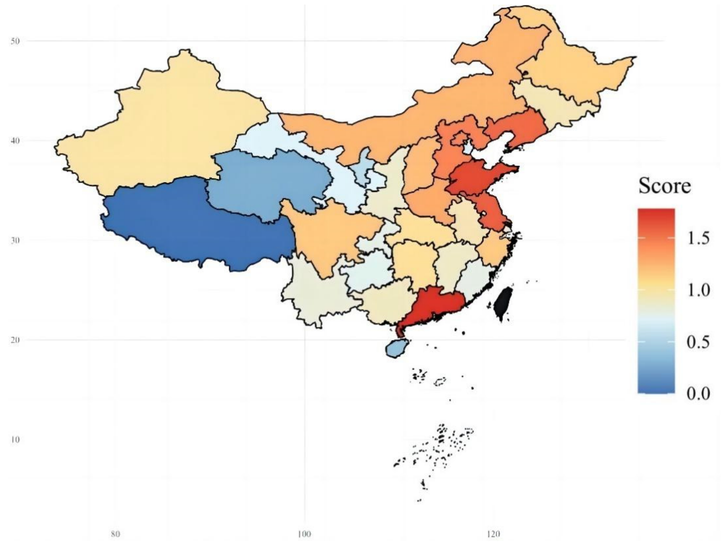


Figure 5: Distribution of overall composite score index by provinces and cities in China

As shown in Figure 6, the time trend of the composite score of Chinese provinces and cities shows that the overall level of China's regional economic growth shows an increasing and then decreasing trend during 2013-2019, with an increasing phase during 2013-2014 and a decreasing phase during 2015-2019, which indicates that these seven years the imbalance of China's regional economic development gradually increased. From the visualization of the composite scores of provinces and cities in Figure 7, it can be seen that the differences in economic development between eastern, northeastern and central parts of China changed more obviously between 2013 and 2019, and the corresponding composite score values all decreased, which is mainly related to resource allocation, industrial structure, regional openness and human capital factors.

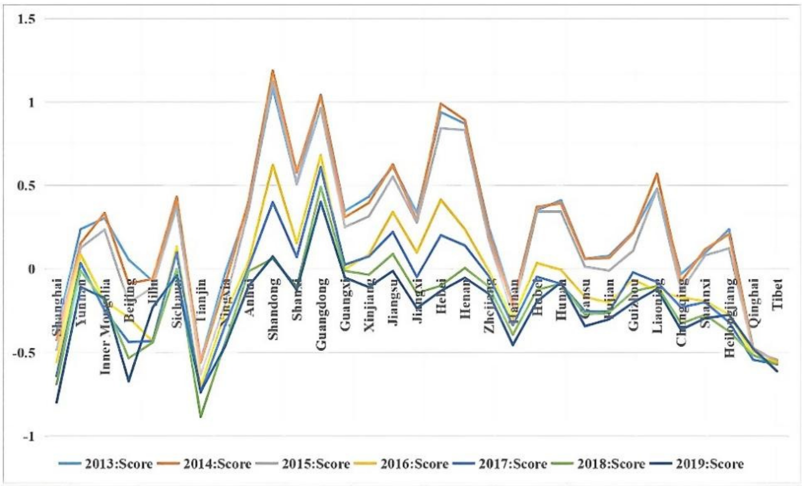
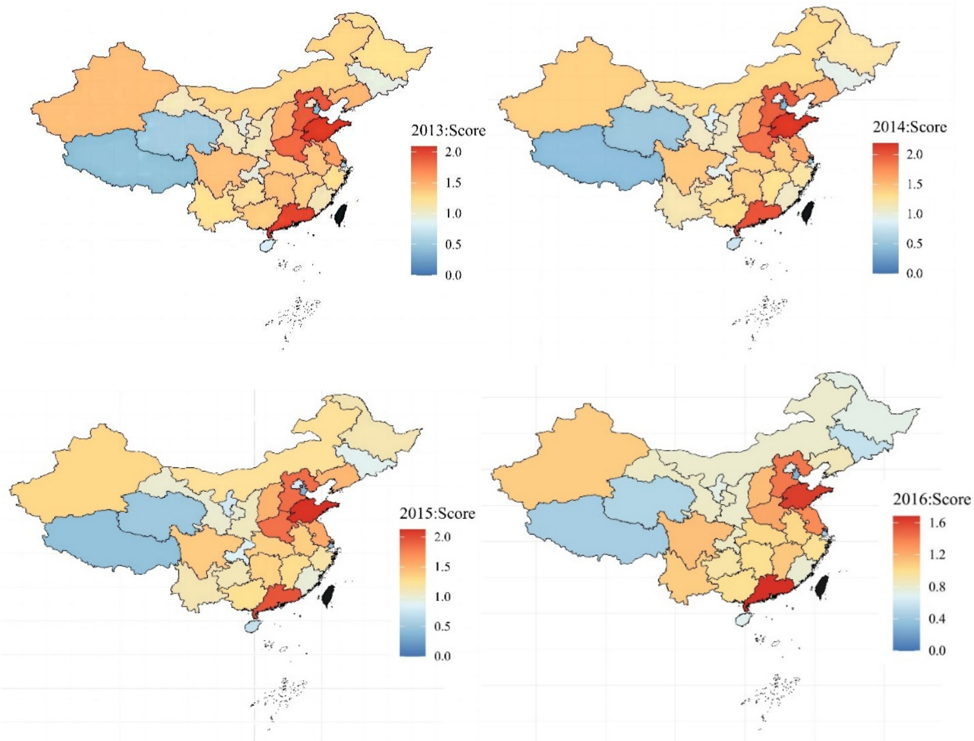


Figure 6: Time trend of composite score by provinces and cities in China, 2013-2019



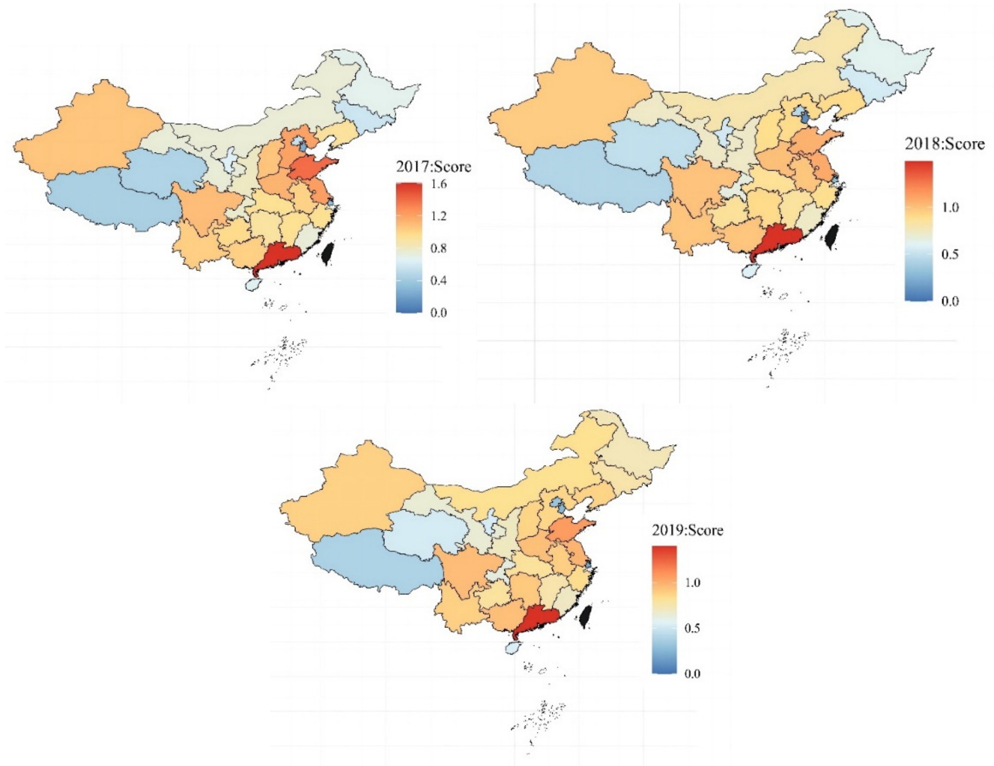


Figure 7: Visualization of composite scores by provinces and cities in China, 2013-2019

4.5.2 Chinese Experience and Empirical Evidence

- In terms of resource allocation, the strengths and weaknesses of inter-regional resource allocation can influence the speed and quality of economic development. However, the unbalanced distribution of resources prevails in most regions of China, which to some extent plays a decisive role in the type and distribution of industries in China, which in turn affects the overall economic development level.

- Considering the industrial structure, with the change of industrial types and cluster locations among Chinese regions, it has influenced the economic development dynamics of most of the eastern, northeastern and central regions, which in turn has accelerated the shift of economic and industrial centers of gravity. The industrial bases, mainly in the Beijing-Tianjin-Hebei Industrial Zone, Liaoning-Zhongnan Industrial Zone and Shanghai-Nanjing-Hangzhou Industrial Zone, have developed toward energy-intensive and high-energy-consuming industries, while the Pearl River Delta Economic Zone has developed toward technology-intensive and outward-oriented industries, mainly in high-tech information technology, which has caused the differences in industrial patterns and clusters between the north and the south of China.

- From the perspective of regional development, China has started to move from the top-level strategic concept to the practical cooperation stage in the 13th Five-Year Plan period, but due to the international environment and industrial structure changes, China is facing downward pressure on the economy as a whole, and the market environment has also undergone formal changes, making China's regional economic growth resistant.

- In the context of human capital, on the one hand, during the period 2013-2019 China's economic development achieved a shift from the deceleration and gear shift phase with rising capital contribution and declining total factor productivity to the new development concept phase; on the other hand, during this period, the number of labor force population in eastern and some central regions of China showed a declining trend, and the total labor input factor year by year. On the other hand, the number of the labor force in eastern and some central regions of China showed a decreasing trend during this period, and the total labor input factors decreased year by year, which in turn reduced the labor transfer effect and made the contribution of total factor productivity to economic growth brought by labor transfer decrease.

5 CONCLUSION

This paper measures the economic growth levels of 31 provinces and cities in inland China and analyzes their influencing factors. Combined with the results of factor analysis, we can see that: (1) there are obvious differences in China's regional economic development. The overall economic development level of the eastern coastal region is higher than that of the western inland region, and the overall trend is a "decreasing ladder" among the eastern, central and western regions, and there is a certain gap between the regions. (2) The economic contribution rate of 31 provinces and cities was measured by the factor composite score function, and the results show that Guangdong, Shandong and Jiangsu have a higher level of economic development and rank in the top three in China, while Hainan, Qinghai and Tibet rank in the bottom three. (3) The characteristic roots, variance contribution rates and cumulative contribution rates of the 14 indicators selected in the article were measured by using principal component analysis, and the results showed that the level of economic development and social living standards are the primary factors affecting the degree of regional economic development. (4) The statistical analysis of spatial and temporal differences shows that four factors, namely, resource allocation, industrial structure, regional openness and human capital, are the key to the imbalance of China's regional economic growth and the breakthrough point for China to achieve high-quality economic development in the future.

In response to the above findings, this paper makes the following recommendations.

- First, optimize the industrial structure of each region, and promote the rationalization, coordination and ecological development of economic industries among regions. For regions with higher degree of economic development, strengthen the support at the level of innovation and technology, and promote industrial transformation and upgrading with technological breakthroughs; for regions with lower degree of economic development, formulate reasonable development plans according to the regional resource and environmental bearing situation, develop low-carbon and green development programs, and realize the green development of industrial economy.

- Second, in view of the differences in economic development between different regions, actively strengthen the economic cooperation and connection between regions. To strengthen the synergy of economic structure, the advantageous regions should focus on maintaining their development advantages and constantly updating innovative technologies to break through the development bottlenecks; the economically backward regions should take the initiative to change and break the traditional economic model, actively learn from the development experience of the excellent regions, rationalize the development measures, and maximize the leading effect of policies to promote the synergistic development of inter-regional economy in order to narrow the development gap in China as much as possible.

- Thirdly, during the 14th Five-Year Plan period, we should pay attention to inter-regional science and technology linkages and improve the level of human capital to empower China's high-quality economic development. Secondly, we should innovate a high-quality economic structure and build a modern market economy system to create an excellent environment and opportunities for China's high-quality and coordinated economic development and to strengthen the foundation of China's regional economic synergy. The last thing is to improve economic infrastructure construction, optimize the layout of industrial structure, curb the coexistence of high development and high energy consumption, and lay a solid foundation for the realization of high-quality economic development.

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