Research of Regional High-quality Development Level

Based on PCA-BP Neural Network

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Abstract. This paper constructs an evaluation index system for high-quality development(HQD) in Anhui province in five dimensions: economic efficiency, structural optimization, innovation drive, opening and green ecology, and then uses PCA to measure the level of high-quality development(HQD) in Anhui province from 2010 to 2021 and gives the corresponding improvement paths, finally uses BP neural network to simulate and predict the level of high-quality development(HQD).

Keywords: High-quality development; data mining; Macroeconomics; PCA; BP neural network

1 Introduction

Global socio-economic development is undergoing a major change unprecedented in a century, in the face of the treacherous international situation and the major strategic need to build a new pattern of domestic and international double cycle, HQD is a major issue facing China's medium and long-term socio-economic development, therefore the issue of development high-quality must be placed in a more prominent position , promoting HQD has become the distinctive banner of new era development. Which requires China to reflect high-quality in all fields and at all levels, including economic, social, cultural and ecological development, all levels must reflect the requirements of HQD[1-2]. Therefore, the measurement of HQD has gradually become a hot spot in academic research and a painful area of research. The regional development difference in Anhui province is obvious, and the regional economic development between the north and the south has many differences. The HQD of Anhui province is facing the double pressure of leapfrog development and coordinated regional development[3]. Therefore, it has great practical value to analyze the level of HQD of Anhui.

In this paper, Anhui Province is selected as the object of research analysis, and the twelve years yearbook data from 2010 to 2021 is selected as the source of indicators. Adhering to the basic principles of comprehensiveness, explanatory power of indicators, and convenience of data collection, a total of 26 secondary indicators are selected under five target layers. In addition, using the method of PCA to measure the level of HQD and provide corresponding improvement paths in the hope of providing

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theoretical support for the HQD of Anhui Province. In addition, we uses BP neural network to predict and simulate the results of HQD. It has been widely used in economy[4-5], production[6] and other fields, and has greatly improved the accuracy of simulation and prediction models.

2 Measurement of high-quality development

Starting from the economic theory[7], innovation ability[8], resource allocation efficiency[9], sustainable development[10] and other dimensions[11-12] are taken as the main factors to build the regional HQD index system. Therefore, this paper starts from five dimensions, and constructs the evaluation system of regional HQD in Anhui Province. After the data standardization, the test results are as follows Table 1.

Table 1. KMO and Bartlett's sphericity test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure Test		0.867
Bartlett's Test of Sphericity	Approx. Chi-Square	125.649
	df	10
	Sig. Bartlett	0.000

The KMO value of 0.867 was obtained from the above. In the KMO metric, a value more than 0.7 indicates a high correlation between the variables. The cumulative contribution of the principal components reached 0.85. The Bartlett's test of sphericity had a p-value of 0.000, rejecting the null hypothesis and indicating the suitability for PCA.

The results of the principal components were achieved through descriptive analysis of the indicator data with the help of factor analysis:

Table 2. Eigenvalues and principal component contributions and cumulative contributions

Ingredients	Initial Eigenvalue			Extraction of squares and loading		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	20.594	79.209	79.209	20.594	79.209	79.209
2	2.737	10.527	89.736	2.737	10.527	89.736
3	1.260	4.846	94.582	1.260	4.846	94.582

The SPSS software was used to analyze the HQD level of Anhui province. According to the principle of 85%-95% cumulative contribution rate of principal component, three principal component factors were selected, as shown in Table 2. The cumulative variance contribution rate of the first principal component was 94.582%, and the cumulative variance contribution rate of the first principal component was 79.209% (W_1). The cumulative variance contribution rate of the second principal component is 10.527% (W_2), and the cumulative variance contribution rate of the third principal component is 4.846% (W_3), which is significantly representative. The three eigenvalues are: $\boldsymbol{\lambda_1}$ =20.594, $\boldsymbol{\lambda_2}$ =2.737, $\boldsymbol{\lambda_3}$= 1.260 and the calculated open-square values of the three eigenvalues are $\sqrt{\lambda_1}$ = 4.538, $\sqrt{\lambda_2}$ = 1.654, and $\sqrt{\lambda_3}$ = 1.122. In line with the requirements for further analysis, further principal component loading values were obtained. As shown in Table 3.

Table 3. Principal component loading values

Indicators	F_1	F_2	F_3
X_1	0.046	0.736	0.541
X_2	0.969	-0.203	-0.009
X_3	0.794	-0.412	-0.114
X_4	0.967	-0.123	-0.054
X_5	0.966	0.206	0.074
X_6	0.967	0.105	0.100
X_1	0.952	0.210	0.051
X_8	0.976	0.158	0.019
X_9	0.993	0.101	0.034
X_{10}	0.981	0.050	0.006
X_{11}	0.985	0.070	-0.059
X_{12}	0.987	0.088	-0.012
X_{13}	0.894	0.357	-0.083
X_{14}	0.964	0.234	0.002
X_{15}	0.944	0.253	0.136
X_{16}	0.937	-0.169	0.126
X_{17}	0.692	-0.094	-0.631
X_{18}	0.951	-0.106	-0.153
X_{19}	0.929	0.196	0.159
X_{20}	0.952	-0.101	-0.199
X_{21}	0.022	-0.934	0.309
X_{22}	0.711	-0.525	0.375
X_{23}	0.993	0.063	0.068
X_{24}	0.924	-0.278	-0.192
X_{25}	-0.691	0.496	-0.348
X_{26}	0.996	0.034	-0.033

According to the principal component loading matrix, each column is divided by the corresponding eigenvalue root value to obtain the corresponding coefficient matrix, i.e., the principal component eigenvector as follows Table 4.

Table 4. Principal component eigenvectors (coefficient matrix)

Indicators	F_1	F_2	F_3
X_1	0.010136487	0.444877474	0.481961106
X_2	0.213527307	-0.122703977	-0.008017837
X_3	0.174964584	-0.249034673	-0.101559272
X_4	0.21308659	-0.07434773	-0.048107024
X_5	0.212866232	0.124517336	0.06592444
X_6	0.21308629	0.063467574	0.089087081

X_1	0.209781214	0.126935149	0.045434411
X_8	0.215069816	0.095503588	0.016926545
X_9	0.218815909	0.061049762	0.030289607
X_{10}	0.216171608	0.030222654	0.005345225
X_{11}	0.217053042	0.042311716	-0.052561378
X_{12}	0.217493759	0.053191872	-0.001069045
X_{13}	0.197000426	0.215789753	-0.073942277
X_{14}	0.212425515	0.141442023	0.001781742
X_{15}	0.208018347	0.152926632	0.12115843
X_{16}	0.206475838	-0.102152572	0.112249722
X_{17}	0.152488025	-0.05681859	-0.562139479
X_{18}	0.209560856	-0.064072027	-0.136303233
X_{19}	0.20471297	0.118472805	0.141648458
X_{20}	0.209781214	-0.061049762	-0.17728329
X_{21}	0.004847885	-0.564559185	0.275279079
X_{22}	0.156674835	-0.317337872	0.334076552
X_{23}	0.218815909	0.038080545	0.060579215
X_{24}	0.203611178	-0.168037959	-0.171047195
X_{25}	-0.152267667	0.299808732	-0.310023041
X_{26}	0.219476984	0.020551405	-0.029398737

Each coefficient vector is multiplied by each indicator vector of the normalization process respectively, which is the score of each principal component. The specific score formula is as follows:

$$F_1=0.010136487X_1 + 0.213527307X_2 + 0.174964584X_3 + ... + 0.219476984X_{26}$$

$$F_2 = 0.444877473X_1 - 0.122703977X_2 - 0.249034673X_3 + ... + 0.020551405X_{26}$$

$$F_3 = 0.481961106X_1 - 0.008017837X_2 - 0.101559272X_3 + ... - 0.02939873X_{26}$$

The principal component synthesis model as follows:

$$F_i = \frac{79.209\%F1+10.527\%F2+4.846\%F3}{94.582\%} \quad (i=2010,2012... .2021)$$

Therefore, the three new indicator variables F_1, F_2 and F_3 were selected to replace the original 26 indicator variables to reflect all the indicator information. After processing the data of each indicator of Anhui provincial quality development level, three new indicator variables (F_1, F_2 and F_3) were obtained through principal component analysis, and the total score of Anhui provincial quality development level was calculated by weighting these three new variables as follows:

$$Z = F_1 W_1 +F_2W_2 +F_3W_3 +... +F_mW_m$$

where Z represents the overall score of Anhui Province's high quality development level, W represents the weight, Fi represents the score of its principal component (i =1,2,3...) , m represents the number of principal components. The composite score of

Anhui province's high quality development level from 2010-2021 is summarized according to this formula. The results as shown in Table 5.

Table 5. Levels of quality development in Anhui provinces 2010-2021

Year	F_1	F_2	F_3	W_1	W_2	W_3	Total score
2010	-7.096276768	2.084956541	-1.642371058	0.79209	0.10527	0.04846	-5.480995791
2011	-5.257764343	-0.71814215	1.130578955	0.79209	0.10527	0.04846	-4.185433527
2012	-3.68523212	-0.13361005	1.148753254	0.79209	0.10527	0.04846	-2.877432058
2013	-2.529385551	-1.22097314	0.168523251	0.79209	0.10527	0.04846	-2.123866207
2014	-0.46016171	-1.58151461	-0.208290958	0.79209	0.10527	0.04846	-0.541069313
2015	1.720987297	-2.13918995	-1.627774986	0.79209	0.10527	0.04846	1.059102326
2016	2.759947804	-1.01426579	0.611065952	0.79209	0.10527	0.04846	2.108967552
2017	3.706990736	0.152402432	0.138231568	0.79209	0.10527	0.04846	2.959012398
2018	4.918540289	1.759136518	-0.099285315	0.79209	0.10527	0.04846	4.076299512
2019	6.224701101	2.895549144	0.422441841	0.79209	0.10527	0.04846	5.255809485
2020	5.697971838	1.837695187	0.376856365	0.79209	0.10527	0.04846	4.725023145
2021	6.531750576	3.358515956	-0.588016924	0.79209	0.10527	0.04846	5.498789989

3 BP neural network simulation

After measuring and analyzing the high-quality development level of Anhui province, this paper uses BP neural network to simulate and predict the regional high quality development level of Anhui Province. The 26 indicators are selected as evaluation indicators of regional high-quality development, so these indicators are input into neurons as BP neural network models. Step 1, it is determined that the number of output data types is 1, the number of neuron network output units is 1, and the result is the calculated high quality development index; Step 2, reasonable control of the number of hidden layer units; Step 3, determine the transfer function (sigmoid function); Step 4: Determine the training function (Trainlm function). In the process of forward propagation of the BP neural network model, the weights and parameters between nodes are repeatedly debugged to find out the parameters with the best accuracy of the operation rate and prediction results, and the target deviation rate of the output results under the number of nodes of different hidden layers is compared in a reasonable area. Finally, through repeated testing, it is confirmed that the BP neural network model with 6 hidden layer nodes, 0.001 target deviation rate, 0.05 learning speed, 1000 training cycles and trainlm is the best R&D cost prediction model at present.

After the training is completed. The correlation degree of prediction results R=0.9764 for the training set of regional high-quality development prediction model based on BP neural network, indicating that the simulation ability and prediction ability of the trained neural network model are relatively accurate. In the following research, the data of the following year can be further predicted. If the result obtained is less than the index of the previous year, it indicates that the regional HQD level of Anhui Province in this year is lower than that of the previous year; otherwise, it is higher.

According to the above analysis of regional HQD prediction, 26 indicators are taken as independent variables of HQD level prediction, and the HQD level of the current year is taken as dependent variables, and a multiple linear regression model is established:

$$Y= a_1X_1 + a_2X_2 + a_3X_3 + ... + a_{26}X_{26} + b$$

Where Y is the HQD level of the predicted year, and X is the respective variable. The SPSS software is used to conduct multiple regression analysis to obtain the results. As shown in Table 6.

Table 6. Comparison of BP neural network with regression

	Actual value	Predicted value	Deviation	Rate of deviation%
BP	5.498789989	5.578934264	0.080144275	1.437
regression	5.498789989	5.235343463	-0.263446526	-5.032

4 Results and suggestions

Although the level of high-quality development in Anhui province from 2010 to 2021 has improved rapidly in general, the level of structural optimization and open environment has a U-shaped distribution. I analyze may be due to the fact that the economy of Anhui province from 2010 to 2015 mostly originated from rough development, which ignored the importance of economic structure and open environment. Besides the level of innovation drive bottomed out in 2015 and then soared in 2019. Anhui Province has gradually and deeply implemented the innovation-driven guideline towards high-quality development, which has contributed to the rapid improvement of the innovation-driven level in Anhui Province.

Therefore, the government should actively promote the concept of ecological civilization and encourage public participation in green behavior. The government decision-makers need to strive to raise the ecological awareness and transform the cultural values. The government system should establish a green performance assessment, and strengthen the sense of environmental responsibility of leading cadres. At the enterprise level, the enterprises should strengthen the production concept of business operations and producers to protect the ecological environment.

The government should accelerate the planning and design of low-carbon cities. Therefore, they must determine the development objectives and strategic of low-carbon cities. The specific approach is developing and improving the low-carbon city evaluation index system. That will provide important standards and bases for regulating the construction of low-carbon cities. We should also improve the diversified financing system for urban infrastructure, establish a multi-level operation mechanism for urban infrastructure. A feasible building energy efficiency standards and energy-saving operation plans for public systems is also necessary. The government should actively promote the development of green energy, smart grid, green buildings and green transportation. That will change the energy structure dominated by coal, petroleum and other petrochemical resources.

The local should seize the opportunity of "The Belt and Road" era to create an open development environment. From the actual situation in Anhui Province, government need improve the province's macro-control mechanism, actively build a service-oriented government. And government should make the image of service-oriented government deeply rooted in people's hearts. We also increase guidance and support for investment promotion along "The Belt and Road" to improve the quality of fiscal revenue across the board. We should always insist on the combination of "bring in" and "going out", and learn to improve the ability to "go out" from "bring in". Which will promote the free flow of goods, services and factors of production, and inject new energy into the high-quality development of Anhui province.

The local should accelerate the development of strategic emerging industries and encourage enterprises to carry out innovation. The local government should promote cooperation between industry, academia and research actively. Besides, the government and enterprises should improve the technological innovation system, and effectively accelerate the transformation of achievements. That will enhance the competitiveness of traditional industries. The government should also integrate existing modern science and technology to develop independent innovation in green technology, safeguard the cultivation and economical use of resources.

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