ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

Evaluation and Research on Carbon Peak Development in 12 Low-Carbon Pilot Cities in China under the Perspective of Green Finance

Qingbo Ru[1, a], Yilin Chen[2], Yunyuan Lan[3], Siyu Shen[4], Langping Tao[1, *]

[1]School of Finance, Anhui University of Finance and Economics, Bengbu, Anhui, China

[2]School of Accountancy, Anhui University of Finance and Economics, Bengbu, Anhui, China

[3]School of Finance and Public Administration, Anhui University of Finance and Economics, Bengbu, Anhui, China

[4]School of International Trade and Economics, Anhui University of Finance and Economics, Bengbu, Anhui, China

[a]2595022250@qq.com, [*]cdtaolp@163.com

Abstract

In September 2020, China for the first time carbon peak, China's green financial development in new opportunities for development, this paper is based on the city in the national carbon emission reduction work, under the background of green finance, through the theoretical analysis of low carbon pilot city carbon peak development analysis, put forward to accelerate the propulsion carbon peak target opinions and Suggestions.

Keywords

Carbon peak, Factor analysis, Cluster analysis, Entropy evaluation method.

1. Introduction

At present, in the research of carbon peak under the background of green finance in China, there are not many analysis and evaluation of the development of carbon peak in low-carbon pilot cities in the existing relevant literature. In order to accelerate the early realization of the goal of urban carbon peak in China, this paper will select 12 pilot cities of low-carbon economy in China as research samples, carry out comprehensive evaluation of factor analysis and cluster analysis, and put forward corresponding suggestions on the existing system policies in China.

2. Research Method

2.1. Entropy evaluation method

The degree of variation of the selected index variables is used to determine the weight of the variables. For the information entropy of the selected evaluation index, the larger the general information entropy, the greater the weight of the index, and the greater the information utility it carries.

2.2. Factor analysis

Factor analysis, through the linear combination of the original variables, the common factor is extracted from the original variable group, so that the meaning of the comprehensive index can replace the original variables, which is conducive to the analysis and treatment of the problem.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

2.3. Clustering methodology

By cluster analysis method, the original data are grouped and classified according to the properties and characteristics of the original data. The original data are similar into one category, and the large properties are different into different categories, which intuitively show the similarities and differences between each data.

3. Empirical Analysis

3.1. Indicator system construction

On the basis of reading a large number of relevant literature, this paper draws on the existing index system of predicting and estimating urban carbon peak. Eight indicators are selected from the four aspects of urban green finance development level, urban economic development level, urban population scale structure, and urban area energy structure, as shown in Table 1.

Table 1. Index evaluation system

Primary indicators	Secondary indicator code	Secondary indicators
Development level of green finance	X1	Green finance Index
Level of urban economic development	X2	Year-end total GDP/100 million yuan
	X3	GDP year-on-year growth rate
Urban population size and structure	X4	Year-end resident population in the region/10000 people
	X5	Average annual growth rate of population/%
Industrial Structure and Energy Environment	X6	Total social electricity consumption/10000 kW • h
	X7	Year-on-year growth rate of total electricity consumption
	X8	Increase rate of added value in industries above designated size/%

3.2. Data Source

This paper is mainly based on the relevant data in 2022, mainly from the websites of the national and provincial bureau of Statistics, the Ministry of Finance, the People's Bank of China and other authoritative institutions and various authoritative statistical yearbooks.

3.3. Research process

Firstly, the entropy method is used to measure the development level of green finance in the selected 12 pilot cities and cluster analysis after factor analysis to discuss the similarities and differences of different categories.

3.3.1. The entropy value method is used to evaluate the development level of green finance

(1) Build an evaluation index system for the development level of green finance

Due to the difficulty in measuring the development level of green finance, the evaluation system is according to relevant literature:

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

Table 2. Evaluation Index System of green finance Development Level

Primary indicators	Secondary indicators	Third level indicators	Definition of tertiary indicators
Development level of green finance	Green credit	Proportion of environmental protection project credit	Total credit for environmental protection projects in the province/total credit for the province
	Green investment	Proportion of investment in environmental pollution control to GDP	Environmental pollution control investment/GDP
	Green insurance	Extent of promotion of environmental pollution liability insurance	Environmental pollution liability insurance income/total premium income
	Green bonds	Development level of green bonds	Total issuance of green bonds/total issuance of all bonds
	Green support	Proportion of fiscal environmental protection expenditure	Financial environmental protection expenditure/general budget expenditure
	Green Fund	Proportion of green funds	Total market value of green funds/total market value of all funds
	Green rights	Depth of green rights development	Total amount of carbon trading, energy trading, emission trading/equity market transactions

(2) Green finance index estimated by entropy weight method

① Data standardization processing

Due to the differences of different indicators, in order to make the indicators of different units can be synthetic, first standardized processing, the calculation formula is as follows.

$$R_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \tag{1}$$

Among them, i represents a low-carbon pilot city; j represents various indicators; Xij is the jth indicator of the i-th pilot city; Rij represents the standardized value of the jth indicator for the i-th low-carbon pilot city.

② Calculate the relevant proportion of the jth project indicator in the i-th city.

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

Where, i=1, .., n； j=1, ..., m.

③ Calculate the information entropy of each index.

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

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

Among them, Uj ≥ 0. If Pij=0, define Uj=0.

④ Calculate the coefficient of difference for each indicator.

$$d_j = 1 - U_j \tag{4}$$

⑤ Determine the weight of each indicator.

$$W_j = \frac{d_j}{K - \sum U_j} (j = 1,2,\ldots,m) \tag{5}$$

⑥ According to the linear weighting method, the development level of green finance in each pilot city is measured, and the quantitative green finance index is obtained.

$$S_i = \sum_{j=1}^{m} W_j P_{ij} \tag{6}$$

Among them, Si refers to the relevant development level of green finance industry in city i. The larger Si is, the higher the development level of green finance.

(3) Entropy weight method evaluation

Using EXCEL, the weights by the entropy method, and the ranking is shown in Table 3.

Table 3. Ranking of green finance Index

City	Green finance Index	Ranking
Shenzhen	0.617316	1
Xi'an	0.497364	2
Xiamen	0.494844	3
Nanjing	0.481068	4
Qinhuangdao	0.4662	5
Wuhan	0.449484	6
Hangzhou	0.43932	7
Jinan	0.431424	8
Changsha	0.421344	9
Chengtu	0.318108	10
Nanchang	0.306516	11
Hefei	0.268632	12

3.3.2. Evaluation of the "carbon peak" in the low-carbon pilot cities by using factor analysis

(1) Adaptability test

Firstly, SPSS23.0 is standardized to eliminate the influence of different dimensions of each index to enable unified data processing; KMO and Bartlett test of the partial correlation matrix of index variables through the software, as shown in Table 4.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

Table 4. KMO and Bartlett's tests

KMO and Bartlett (Bartlett) test		
KMO sampling suitability quantity		0.558
Bartlett sphericity test	Approximate chi square	59.704
	Freedom	28
	Significance	0.000

According to Table 4, the KMO value is 0.558, which is greater than the critical value of 0.5; the spherical degree test result of Bartlett (Bartlett) shows that the significance of the evaluation index is 0.000, less than 0.05; so the selected index is suitable for factor analysis.

(2) Extracting the factor variables

The SPSS software is used to extract four factors and obtain the total variance interpretation table. From Table 5, although the characteristic value of the fourth factor is less than 1, the contribution of the factor is slightly less than 1; the cumulative contribution of the top four factors is 91.365%, including 91.365% of all the index information, which can be used to extract factor variables.

Table 5. Explanation of total variance

Principal component	Initial eigenvalue			Extract the sum of squares of the load		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	3.829	47.866	47.866	3.829	47.866	47.866
2	1.574	19.671	67.537	1.574	19.671	67.537
3	1.155	14.439	81.976	1.155	14.439	81.976
4	0.751	9.389	91.365	0.751	9.389	91.365
5	0.464	5.803	97.168			
6	0.165	2.062	99.231			
7	0.039	0.494	99.724			
8	0.022	0.276	100			

(3) Factor rotation

In order to reduce the number of variables of the extracted factor, and make its explanatory force more prominent, it can show obvious differences. For factor rotation using the maximum variance orthogonal rotation method, the resulting rotated component matrix is shown in Table 6.

As can be seen from the factor component matrix obtained after rotation, factor 1 has the total GDP at the end of Zscore (X2), the permanent resident population at the end of Zscore (X4), and the maximum load on the total electricity consumption at the end of Zscore (X6), which can be named as economic development factor F1. Factor 2 has a maximum payload in the Zscore (X1) green financial index, and can be named as the green financial factor F2. Factor 3 has the maximum load in the year-on-year GDP growth rate of Zscore (X3), the year-on-year growth rate of Zscore (X7), and the increase rate of industrial added value above Zscore (X8), which can be named as industrial economic factor F3. Factor 4 is the annual growth rate of Zscore (X5), which can be named as population structure factor F4.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

Table 6. Component matrix after rotation

Indicator	Principal component			
	1	2	3	4
Zscore(X1)	0.06	0.907	0.114	-0.099
Zscore(X2)	0.861	0.406	-0.126	0.220
Zscore(X3)	-0.645	0.165	0.514	-0.333
Zscore(X4)	0.972	0.044	0.103	-0.019
Zscore(X5)	0.149	-0.092	-0.012	0.977
Zscore(X6)	0.907	0.279	-0.223	0.133
Zscore(X7)	-0.346	-0.756	0.325	0.035
Zscore(X8)	-0.05	-0.089	0.976	0.015

(5) Factor Score

The scores of the four extracted factors were calculated by the regression method of SPSS software. Secondly, according to the contribution rate of the extracted load squares after factor rotation is shown in Table 7, the F comprehensive factor score is calculated, and its linear expression is F=F1×0.38394 + F2×0.21207 + F3×0. 17650 + F4×0.140.

The calculated comprehensive factor score is shown in Table 8.

Table 7. Explanation of total variance after rotation

Principal component	Initial eigenvalue			Extract the sum of squares of the load		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	5.350	53.497	53.497	3.072	38.394	38.394
2	1.666	16.655	70.152	1.682	21.027	59.422
3	1.109	11.090	81.242	1.412	17.65	77.072
4	0.720	7.195	88.437	1.143	14.293	91.365

Table 8. Factor Score and Comprehensive Score

City	F1	F2	F3	F4	F	Ranking
Shenzhen	1.1432	2.5481	-0.0109	0.8246	1.0906	1
Xi'an	0.2691	-0.1046	2.3766	-0.0176	0.4983	2
Chengtu	1.8830	-1.0695	-0.0782	-1.5108	0.2684	3
Changsha	-0.3464	0.0220	0.8988	1.2966	0.2156	4
Wuhan	0.5236	-0.2397	0.2700	-0.7489	0.0913	5
Nanjing	0.3130	-0.0113	-0.2993	-0.2095	0.0350	6
Hangzhou	0.5818	-0.0698	-1.6493	0.5564	-0.0029	7
Hefei	-0.1824	-1.2936	0.0030	1.1536	-0.1766	8
Jinan	-0.4307	-0.0710	-1.1942	-0.0014	-0.3913	9
Nanchang	-0.9210	-0.9117	-0.0802	0.9164	-0.4285	10
Xiamen	-1.1304	0.4291	-0.4302	-0.5302	-0.4955	11
Qinhuangdao	-1.7028	0.7721	0.1940	-1.7293	-0.7044	12

From the data sheet, the economic development factor F1 shows the correlation between the total GDP at the end of Zscore (X2), the permanent population in the region at the end of Zscore (X6). Chengdu and Shenzhen lead other cities, indicating that Shenzhen and Chengdu can reasonably grasp the relationship between energy consumption and economic income and expenditure. Regarding green finance factor F2, it shows the relationship between the

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

promotion of carbon peak and the development degree of urban green finance Zscore (X1) green finance index; Shenzhen is higher, indicating that green finance is larger in the economic structure and the development degree is good. As for industrial economic factor F3, it indicates the correlation between the year-on-year growth rate of Zscore (X3) GDP, the year-on-year growth rate of social electricity consumption in Zscore (X7) and the increase rate of industrial added value above Zscore (X8); among them, Changsha has the highest score, indicating that the growth rate of industrial economy and the year-on-year growth rate of urban GDP and the year-on-year growth rate of electricity consumption in the whole society are more prominent. Regarding the population structure factor F4, it shows that the average annual population growth rate of Zscore (X5) has a positive impact on carbon peak; Changsha and Hefei have higher scores, indicating that these cities have good population structure, higher vitality, and better development prospects in the future, and the process of carbon peak can be promoted faster.

From the perspective of comprehensive score ranking, on the premise of considering the development level of green finance, Shenzhen, Xi'an and Chengdu are relatively fast and are expected to reach the carbon peak in advance. The results are more in line with the reality. Firstly, most of the single factors are positive, and the development level of green finance increases the GDP of other cities. It shows that the promotion of carbon peak is closely related to the development of green finance.

3.3.3. Evaluation of "carbon peak" in low-carbon pilot cities by cluster analysis

By selecting the single factor scores obtained by the above factor analysis and the comprehensive factor score variables for cluster analysis of the selected cities, the mean scores of all factors are calculated as shown in Table 9 and 10.

Table 9. Cluster Analysis of 12 Cities

City	F1	F2	F3	F4	F	Category
Shenzhen	1.1432	2.5481	-0.0109	0.8246	1.0906	1
Changsha	-0.3464	0.0220	0.8988	1.2966	0.2156	
Hangzhou	0.5818	-0.0698	-1.6493	0.5564	-0.0029	
Xi'an	0.2691	-0.1046	2.3766	-0.0176	0.4983	2
Chengtu	1.8830	-1.0695	-0.0782	-1.5108	0.2684	
Wuhan	0.5236	-0.2397	0.2700	-0.7489	0.0913	
Nanjing	0.3130	-0.0113	-0.2993	-0.2095	0.0350	
Hefei	-0.1824	-1.2936	0.0030	1.1536	-0.1766	
Jinan	-0.4307	-0.0710	-1.1942	-0.0014	-0.3913	
Nanchang	-0.9210	-0.9117	-0.0802	0.9164	-0.4285	
Xiamen	-1.1304	0.4291	-0.4302	-0.5302	-0.4955	
Qinhuangdao	-1.7028	0.7721	0.1940	-1.7293	-0.7044	

Table 10. Mean Scores of Various Factors

Category	F1	F2	F3	F4	F
Category 1	0.4595	0.8334	-0.2538	0.8925	0.4344
Category 2	-0.1532	-0.2778	0.0846	-0.2975	-0.1448

By table 9, table 10, the first category mainly includes three cities (Shenzhen, Changsha, Hangzhou), the city's economic development factor F1, green financial factor F2, demographic factor F4 average score is higher, characterized by the end of the GDP, green financial development level, industrial output increase rate, population growth rate is relatively high.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

Although the development level of Qinhuangdao city is relatively low, the development degree of green finance is relatively high. Overall, it is relatively balanced, and there is still a lot of room for development in the future. The second category mainly includes 9 cities. Although the average score of each factor is slightly different from that of the first category, different cities have their own advantages. For example, in the economic development factor of Chengdu F1 score is highlights that its larger live in economic growth, Qinhuangdao in green financial factor F2 compared with the second type of other cities, Hefei in population structure factor F4 performance is the best, can show the side economic development vigor. Therefore, in general, the development of all kinds of cities should be on the premise of stabilizing the current advantageous projects, vigorously develop weak projects, pay attention to the long-term development of economy, seriously adjust other deficiencies, and strive to promote the process of urban carbon peak.

4. Conclusions and Suggestions

4.1. Conclusions

Through comprehensive evaluation and analysis, it is found that: ① Different cities have great differences in the carbon peak development evaluation system, and the main influencing factors affecting economic development are different. ② The economic development level of the selected pilot cities and the development level of green finance are the significant factors affecting the promotion of their carbon peak. The top cities have obvious advantages in the green finance index and GDP growth rate. ③ Among the four factors, through SPSS analysis, it can be found that fast GDP growth, high green finance index, cities with fast industrial growth above designated size often have good development potential and faster carbon peak rate. ④ The carbon peak promotion in low-carbon pilot cities is related to the scale of local industrial resource structure.

4.2. Suggestions

Based on the above conclusions, the following suggestions are put forward: ① Urban financial economy can play the role of green finance in related economic fields, and promote green financial products and derivatives. ② Local governments can take corresponding policies according to the development situation of local cities, rationally allocate resources, and increase the expenditure of green finance policies. ③ Cities and cities can optimize the energy supply and energy consumption of industries above designated scale, promote the use of clean energy and reduce carbon emissions. ④ Based on the gradual promotion of China's new development pattern of international and domestic double cycle, grasp the relevant national policies.

Acknowledgment

This research is funded by the Anhui Provincial University of Finance and Economics Undergraduate Innovation and Entrepreneurship Training Program in 2022 (No.:S202210378275).

References

[1] Yang Shuili, Shi Tong, Wang Chunxi, etc. The influence of the coupling relationship of industry-university-research cooperation on the transformation performance of scientific and technological achievements -- The intermediary role of organizational learning [J]. Science and Technology Management Research, 2019,39 (04): 211-217.

[2] Wu Weiwei, Shi Jian, Liu Yexin. Responsibility for technological innovation: Dimension and Measurement [J]. Scientific Research, 2022,40 (12): 2258-2271.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0029

[3] Wang Yanhong. Research on the investment value of listed companies based on principal component and cluster analysis [J]. Inner Mongolia Science and Technology and Economy, 2022 (12): 50-51 + 54.

[4] Li Jie. Research on the dynamic mechanism of manufacturing transformation and upgrading based on the diffusion of information network technology [D]. Shandong University, 2019.

[5] Liu Hongli. Study on the influence of green finance on green total factor productivity [D]. Shanxi University of Finance and Economics, 2023..

[6] Zhang Li. Research on the economic and environmental effects of Green Finance Development in China [D]. China University of Mining and Technology, 2019.