Green Economy Evaluation of Commercial Banks Based on Data Mining and Game Theory Combination of Optimal Weights

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Abstract: With the introduction of the "double carbon" target, China's economy will be transformed into a low-carbon one. Commercial banks, as the most influential, numerous, and extensive financial institutions in the financial market, play a massive role in realizing this goal through their green financial construction. This paper constructs a green finance evaluation system based on data mining and game theory combination to optimize weights by selecting green economy index data of eight commercial banks between 2016 and 2020. It constructs a weighted standardized decision matrix for green economy evaluation through the TOPSIS evaluation model. It makes an objective, scientific, and fair, comprehensive evaluation score on the construction of green finance for commercial banks. Measuring the current status of green finance development is of great significance.

Keywords: commercial banks, green finance, game theory, grey correlation analysis

1. Introduction

The carbon emission reduction targets of reaching the peak by 2030 and becoming carbon neutral by 2060 are significant decisions made by the Party Central Committee in response to the global rise in greenhouse gases, which will lead to a climate catastrophe for mankind, and are solemn commitments made by China to the rest of the world. It means that China's economy will be transformed into a low-carbon one, and as finance is at the heart of the modern economy, the development of green finance is urgent. Green finance refers to economic activities that support environmental improvement, climate change, and the economic and efficient use of resources. Compared with traditional finance, the most prominent feature of green finance is that it places more emphasis on the interests of human society's survival and environment and takes the degree of effective use of environmental protection and resources as one of the criteria for measuring the effectiveness of its activities, guiding all parties through its activities to focus on the ecological balance of nature.

Commercial banks, as the most important institutions for the distribution of funds in economic activities, can fully represent the overall development of China's green economy in terms of their level of green economy construction. Therefore, it is important to establish a scientific and objective green economy evaluation system and to rate commercial banks to motivate them to increase their green economy reform efforts to develop the green economy. Currently, the British scholar Benny (2001) has constructed an index to evaluate the relationship between banking channels and green performance, evaluating the performance of banking channels in saving energy and protecting the environment in the operation process through indicators such as energy saving in buildings, water application and electricity application [1]. The scholar Wang Tianyu combined the balanced scorecard, economic value-added, and hierarchical analysis to construct a green finance performance evaluation system for Industrial Bank, which can evaluate the implementation of green finance in Industrial Bank from four dimensions of the balanced scorecard: financial, customer, internal process

and learning and growth [2]. The existing literature is of excellent guidance in constructing the evaluation system and selecting evaluation methods. However, most of them only adopt subjective methods to determine the weights of the indicators in the green economy evaluation system, and the evaluation objects are mainly the green economy level of a single bank. There is a lack of research on the comparative analysis of individual commercial banks' green economy development level.

Based on theories and existing research on the green economy of commercial banks, this paper selects eight commercial banks from 2016 to 2020 as research objects. A green financial evaluation system based on data mining and game theory combination is used to optimize the weights. It is constructed, and the TOPSIS evaluation model is used to comprehensively evaluate the green financial development of each commercial bank, with four main innovations as follows[3].

I. The use of grey correlation analysis filters the indicators, eliminates irrelevant variables, and makes up for the regret caused by using mathematical and statistical methods for systematic analysis.

II. Selecting green economy indicators related to eight commercial banks for the period 2016-2020, covering the processing and analysis of qualitative and quantitative data to make the indicator system more comprehensive and objective.

III. The subjective weights are determined by the AHP method, the subjective weights are modified by the entropy method, and finally, the combination weights are obtained based on the game theory, which effectively reduces the subjectivity of the subjective method and improves the scientificity of the objective method.

IV. The TOPSIS model was used to calculate the optimal and inferior solutions of the assessment indicators and the relative closeness of each sample indicator's vector of assessment values to the optimal solution. The green economy score of each commercial bank was derived.

2. Model introduction

2.1 GRA

Based on the principle of observability and considering the availability of indicators, commercial banks' green finance evaluation indicators were initially screened and indicators for which data were unavailable were removed. Regarding the basic methods of factor analysis, mainly using methods such as regression analysis, again with the limitation of sample capacity, there were obvious shortcomings in the six indicators we selected and used to evaluate the whole green credit indicators. Therefore, regarding (Guizhi You, Dazhong Bao, 2008) [4], we analyzed the degree of correlation between the developmental changes of each indicator factor through the method of grey correlation analysis. The degree of interrelationship between indicators is measured quantitatively, and their main influencing factors are identified to estimate the importance of commercial banks' green economy indicators and provide a basis for green economy improvement measures of commercial banks in China.

Translated with www.DeepL.com/Translator (free version). Firstly, on account of metrics data differences, we decentered the n-dimensional secondary indicators and standardized the data by unifying the scale：

$$\boldsymbol{z_{ij}} = \frac{\boldsymbol{x_{ij}-\mu_j}}{\boldsymbol{s_j}} \ \left(\boldsymbol{u_j}=\frac{\boldsymbol{1}}{\boldsymbol{m}}\sum_{\boldsymbol{i=1}}^{\boldsymbol{m}} \boldsymbol{x_{ij}^2},\ \boldsymbol{s_j} = \sqrt{\frac{\boldsymbol{1}}{\boldsymbol{m-1}}}\sum_{\boldsymbol{i=1}}^{\boldsymbol{m}}(\boldsymbol{x_{ij}}-\boldsymbol{\mu_j})^{\boldsymbol{2}}\right) \tag{1}$$

After that, indicator series are selected as the reference series for multiple gray correlation analysis in turn, and each set of reference indicators is designated as the characteristic series $X0$， $X0 = Kj$， $(j = 1,2,3,\dots,n)$(where Kj is the value of the corresponding variable indicator for the jth sample, x_{ij} is the original value of the jth sample of the ith indicator data)

$$\mathrm{D}=\begin{bmatrix} k1 & \cdots & kn \\ x11 & \cdots & x1n \\ \vdots & \ddots & \vdots \\ xm1 & \cdots & xmn \end{bmatrix} \tag{2}$$

And then, we performed a gray correlation analysis according to the following steps:

Firstly, it is calculated the difference sequences:

$$\Delta i_j = \left| k_j - x_{ij} \right| \tag{3}$$

Secondly, it is calculated the extreme differences:

$$a = min(i)\, min(k) \left| k_j - x_{ij} \right| \tag{4}$$

$$b = max(i)\, max(k) \left| k_j - x_{ij} \right| \tag{5}$$

(where a is the minimum difference between the two poles while b is the maximum difference between the two poles)

Third, calculate the correlation coefficients and obtain the evaluation matrix. According to the gray system theory, the optimal series is used as the reference series, and the other is used as the compared series. The correlation coefficient of the jth index of the ith evaluation variable and the jth related variable e_{ij} is obtained by correlation analysis: (The resolution factor ρ is usually taken as 0.5):

$$e_{ij} = \frac{a + \rho b}{\Delta i_j + \rho b} \tag{6}$$

Fourth, calculate correlation:

$$r_j = \frac{1}{n} \sum_{j=1}^{n} e_{ij} \tag{7}$$

Fifth, change the parent series, in turn, to find the correlation matrix R and obtain the table of correlation values shown in Table 1:

Table 1 Correlation matrix R

	A1	A2	A3	A4	A5	A6	B1	B2	B3	C1	C2	D1	D2	D3	D4	D5	E1	E2
A1	1																	
A2	0.63	1																
A3	0.61	0.58	1															
A4	0.70	0.71	0.66	1														
A5	0.73	0.68	0.72	0.77	1													
A6	0.67	0.80	0.62	0.79	0.71	1												
B1	0.75	0.78	0.61	0.79	0.75	0.84	1											
B2	0.59	0.62	0.79	0.71	0.77	0.70	0.67	1										
B3	0.66	0.61	0.66	0.65	0.73	0.63	0.70	0.65	1									
C1	0.57	0.62	0.76	0.58	0.70	0.62	0.61	0.66	0.77	1								
C2	0.69	0.76	0.75	0.60	0.74	0.65	0.65	0.63	0.65	0.77	1							
D1	0.62	0.73	0.73	0.75	0.76	0.70	0.70	0.74	0.59	0.69	0.68	1						
D2	0.64	0.74	0.74	0.71	0.78	0.70	0.70	0.73	0.63	0.72	0.69	0.92	1					
D3	0.66	0.74	0.74	0.72	0.80	0.71	0.71	0.74	0.62	0.72	0.70	0.91	0.96	1				
D4	0.59	0.71	0.66	0.66	0.71	0.70	0.69	0.71	0.61	0.70	0.64	0.65	0.66	0.66	1			
D5	0.67	0.69	0.59	0.75	0.66	0.74	0.77	0.66	0.54	0.57	0.63	0.62	0.58	0.59	0.70	1		
E1	0.54	0.62	0.68	0.64	0.67	0.60	0.61	0.66	0.63	0.75	0.66	0.65	0.66	0.65	0.66	0.63	1	
E2	0.60	0.65	0.74	0.68	0.68	0.63	0.64	0.71	0.56	0.63	0.62	0.70	0.69	0.70	0.59	0.63	0.66	1

Sixth, analysis of the correlation matrix:

Taking the first column (return on net assets) as an example, in order of relevance in the table, there is :0.78>0.77>0.73>0.73>0.71>0.70>0.68>0.67>0.66>0.65>0.64>0.64>0.63>0.63>0.61, resulting a correlation sequence [1.1 1.8 1.5 1.3 1.7 1.2 1.14 1.11 1.15 1.4 1.16 1.12 1.9 1.17 1.6 1.18 1.13], which shows that the biggest influence on it is the cumulative green finance customers. At the same time, we can get the correlation of the other columns, discovering that customer satisfaction is relatively the least significant impact on other indicator factors. Rather, in general, these indicators have a good correlation between them. Moreover, we find that the average value of each column in the correlation matrixε_i: $\varepsilon_5 > \varepsilon_{14} > \varepsilon_{13} > \varepsilon_7 > \varepsilon_{12} > \varepsilon_4 > \varepsilon_8 > \varepsilon_6 > \varepsilon_3 > \varepsilon_2 > \varepsilon_{11} > \varepsilon_{10} > \varepsilon_{17} > \varepsilon_{15} > \varepsilon_{16} > \varepsilon_{18} > \varepsilon_1 > \varepsilon_9$. It can be found that there is the strongest correlation between the green credit ratio and other indicators as the dominant factor, as a result of which we can propose a comprehensive promotion of the optimization of the green financial evaluation of commercial banks in terms of improving the green credit ratio.

2.2 Weighting based on game theory

The weighting of indicators is an essential part of the green economy evaluation of commercial banks. The reasonableness of weighting can directly affect the reasonableness and accuracy of evaluation results. In this paper, we use the game theory integrated weighting method, combine the entropy method and AHP, and use the weights obtained by the game theory method as the final integrated weights of indicators, so that the advantages and disadvantages of the three methods can complement each other in the process of solving the weights of indicators.

2.2.1 Entropy method

The entropy method is one of the objective assignment methods. Determining the weights according to the entropy method can avoid the interference of human factors and is more credible than the weights determined by the subjective assignment method[5]. The entropy method is based on the size of the information conveyed by the index to determine the weight, and it is maturely applied in all kinds of analysis and evaluation, so this paper selects the entropy method to assign the value to the index objectively.

⑴ construction of indicator data matrix

In this paper, we need to evaluate the green economic development level of m commercial banks, and according to the green economic development index evaluation system established in the previous paper, if we consider the green economic development index value of each commercial bank as a subsystem, it includes m subsystems, and there are n evaluation indicators under each subsystem, the raw data matrix is

$$\begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \tag{8}$$

⑵ Standardized raw data matrix

The raw indicator data collected in this paper is not uniform in measurement standards, and the types of indicators vary, including the cost- and benefit-based indicators. A standardization method was used to dimensional Ise the original matrix A. The standardization methods used for the different types of indicators are as follows.

For cost-based indicators, let $\boldsymbol{x_{ij}^{*}} = \frac{\boldsymbol{x_{ij}-min\{x_{1j},\cdots,x_{mj}\}}}{\boldsymbol{max\{x_{1j},\cdots,x_{mj}\}-min\{x_{1j},\cdots,x_{mj}\}}}$ (9)

For benefit-based indicators, let $\boldsymbol{x_{ij}^{*}} = \frac{\boldsymbol{max\{x_{1j},\cdots,x_{mj}\}-x_{ij}}}{\boldsymbol{max\{x_{1j},\cdots,x_{mj}\}-min\{x_{1j},\cdots,x_{mj}\}}}$ (10)

Obtain the normalization matrix of the index data：$\boldsymbol{X^{*}=\{x_{ij}^{*}\}_{m\times n}}$

⑶ Calculation of weights and evaluation values

In the first step, calculate the probability distribution value of each index: $p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$ (11)

The second step is to calculate the index entropy. Assuming that the entropy of the jth index is defined as e_j, the entropy of the jth evaluation index can be defined as：

$$e_j = -\frac{1}{\ln(m)} \sum_{i=1}^{m} p_{ij} \ln(p_{ij}) \tag{12}$$

The third step is to calculate the information entropy redundancy: $d_j = 1 - e_j$ (13)

In the fourth step, calculate the weight of each index: $w_j = \frac{d_{ij}}{\sum_{j=1}^{n} d_{ij}}$ (14)

In the fifth step, using the above calculation results, the total evaluation value of green economic development of each evaluation object can be calculated according to formula (15):

$$F_j = \sum_{j=1}^{n} w_{ij}\, x_{ij}^{*} \tag{15}$$

2.2.2 AHP

The hierarchical analysis method (AHP) with systematic nature used in this paper, hierarchical analysis is a method to determine the weights of each level of the index system through quantitative data processing and analysis, comparison, and judgment based on expert opinions, which can avoid the subjectivity of experts giving weights directly and the dependence of the entropy weight method on sample data, and is a simple, flexible and practical multi-criteria decision method [6-7]. Its calculation steps are as follows:

⑴ Build a hierarchical analysis structure model.

⑵ Calculation of the weight vector w for each level of the indicator.

①Constructing the judgment matrix A：The judgment matrix was constructed using the 1 to 9 and its inverse scale method to represent the importance of indicators at the same level relative to the

upper-level elements, $a_{ij}(\mathrm{i}=1,\cdots,\mathrm{n},\mathrm{j}=1,\cdots,\mathrm{n})$is used to indicate the relative importance of the two elements a_i and a_j.

$$A=\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{1n} & \cdots & a_{nn} \end{bmatrix} \tag{16}$$

②Calculate the maximum eigenvector λ_{max} and the eigenvector of the judgment matrix A to determine the weight vector.

③ Conducting Consistency test：

Consistency indicators $CI=\frac{\lambda_{max}-n}{n-1}$、Consistency ratio $CR=\frac{CI}{RI}$ (17)

If $CR<0.1$, the consistency test of the judgment array moments is considered to pass.

2.2.3 Game Theory

The evaluation indexes of the green economy are assigned with game theory combination weights, the subjective weights are determined by the AHP method, and the subjective weights are modified by the entropy weight method. Finally, the combination is assigned and used to determine the weights of the green economy with certain rationality. By analyzing the equilibrium and coordination between different assignment methods, the subjectivity of the subjective assignment method can be effectively reduced, and the scientific nature of the objective assignment method can be improved [8-10]. From this, the game theory weighting model of this paper is derived.

Let L weight vectors be calculated using L different weighting methods：

$$w_k=[w_{k1},w_{k2},\cdots,w_{kn}],\mathrm{k}=1,2,\cdots,L$$

Construct a basic set of weight vectors: $w=[w_1,w_2,\cdots,w_L]$. Any linear combination of these weight vectors constitutes a set of possible weights：

$$w=\sum_{k=1}^{L}\alpha_k\,w_k^{\mathrm{T}}\ \ (\alpha_k>0) \tag{18}$$

where α_k is the weight coefficient; w is the vector of possible weights.

Finding the optimal weight vector w^* is a matter of minimizing the departure of w from each w_k：

$$min\left\|\sum_{j=1}^{L}\alpha_k w_j^T-w_i^T\right\|,\ \ i=1,2,\cdots,L \tag{19}$$

The optimal first-order derivative condition of the above equation is obtained according to the differential nature of the matrix as: $\sum_{j=1}^{L}\alpha_k w_i w_j^{\mathrm{T}}=w_i w_j^{\mathrm{T}}$, $\mathrm{i}=1,2,\cdots,L$. Solving for $(\alpha_1,\alpha_2,\cdots,\alpha_L)$ and normalizing gives $\alpha^*=[\alpha_1^*,\alpha_2^*,\cdots,\alpha_L^*]$, and finally, the combined weight w^*：

$$w^*=\sum_{k=1}^{L}\alpha^*\,w_k^{\mathrm{T}} \tag{20}$$

2.3 TOPSIS evaluation model

⑴ construction of a weighted standardized decision matrix for green economy assessment

Multiply the (9(((dimensionless indicator data standardization matrix$B_{mn}=\{b_{ij}\}_{m\times n}$with the combined weight vector $w=[w_1,w_2,\cdots,w_n]$ calculated by the game theory method to obtain the weighted standardized decision matrix $R_{mn}=\{r_{ij}\}_{m\times n}$。

$$r_{ij}=w_j\times b_{ij} \tag{21}$$

⑵ Calculating optimal and inferior solutions for performance evaluation indicators

optimal solution vector $X^+=(r_1^+,r_2^+,\cdots,r_n^+)$

inferior solution vector $X^-=(r_1^-,r_2^-,\cdots,r_n^-)$

where $r_j^+=\max_i\{r_i^+\}$, $r_j^-=\max_i\{r_i^-\}$, and $i=1,2,\cdots,m,j=1,2,\cdots,n$

⑶ Calculate the distance from the normalized decision vector weighted by the sample assessment metrics to the optimal and inferior solutions d^+ and d^-

$$\boldsymbol{d_i^+}=\sqrt{\sum_{j=1}^{n}(\boldsymbol{r_j^+}-\boldsymbol{r_{ij}})^2}\text{、}\ \boldsymbol{d_i^-}=\sqrt{\sum_{j=1}^{n}(\boldsymbol{r_j^-}-\boldsymbol{r_{ij}})^2} \tag{22}$$

⑷ Calculate the relative closeness of the vector of evaluation values of each sample indicator to the optimal solution D_i, and use this as the combined evaluation value y_i

$$\boldsymbol{D_i = \frac{d_i^-}{d_i^- + d_i^+} = y_i} \tag{23}$$

y_i is the overall evaluation score of each evaluation object, the larger the value of y_i. The better the overall value of the Green Economy Index. Conversely, the worse the overall value of the Green Economy Index.

3. Evaluation of Green Economy Development of Commercial Banks

3.1 Data sources and processing

It is checked relevant statistics, due to the unavailability of relevant indicators and the absence of some data, this paper selects eight commercial banks with relatively complete and representative data for the study. In March 2016, the National People's Congress adopted the 13th Five-Year Plan, and in August of the same year, the People's Bank of China and seven other ministries and commissions jointly issued the Guidance on Building a Green Financial System, elevating the building of a green financial system to the height and requirements of a national strategy. In this context, 2016 is the first year of green finance in China. Therefore, this paper analyses the indicators of commercial banks' green economy development from 2016 to 2020. The data collected for the analysis of commercial banks' green economy development indicators for the period 2016-2020 were obtained directly or indirectly from the China Statistical Yearbook, the annual external financial statements, annual statements, social responsibility statements of the eight commercial banks, and the China Economic and Social Development Statistical Database.

In collecting raw data, the raw data collected needed to be processed accordingly due to the different data types and the different measurement units for specific indicators. As some data are disaggregated and cannot be obtained directly, questionnaires were used to obtain this part of the data. In order to make the data research and analysis results more objective and accurate, we designed the questionnaire in accordance with the normative requirements of the entropy method. A total of 246 questionnaires were distributed, and 232 were returned, with a return rate of 94.3%.

3.2 Calculation of green economy indicator weights for commercial banks

In this paper, there are five main influencing factors for evaluating the green economic development of commercial banks: financial, customer, employee, internal bank, and external bank. In this paper, the evaluation of green economy development of commercial banks is taken as the target layer: 5 indicators are taken as the criterion layer; 18 secondary indicators are taken as the sub-criteria layer (15 benefit-based indicators and three cost-based indicators are selected), forming the evaluation index system of green economy of commercial banks. (Figure 1)

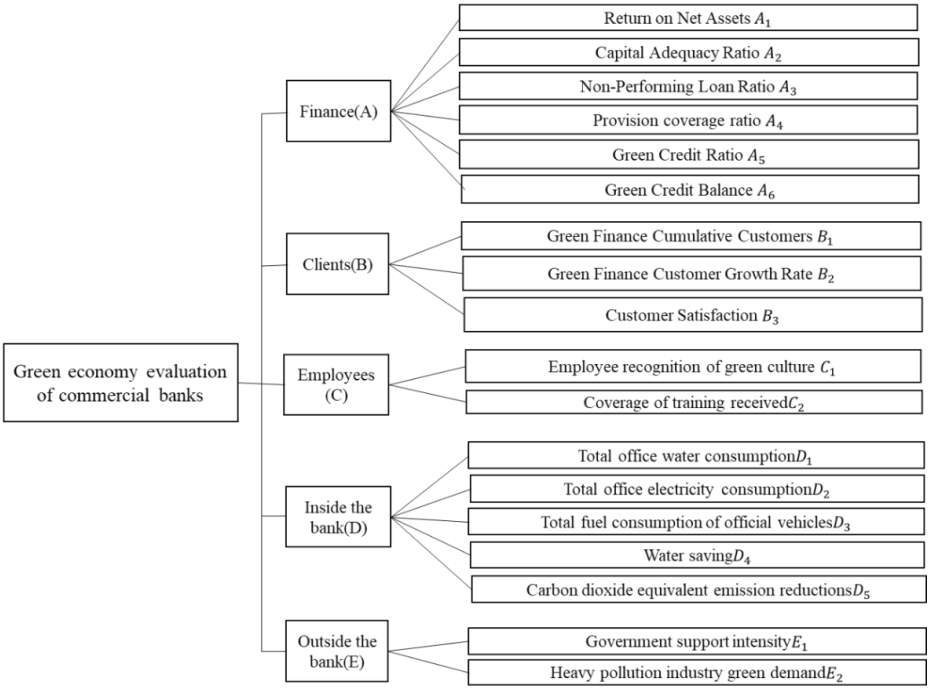

Figure 1 Green economy evaluation index system for commercial banks

After determining the index system for measuring the level of green economy development, the entropy weight method, AHP, and game theory were used to measure the weight coefficients of each index for eight commercial banks from 2016 to 2020, and the results are shown in Table 2. The radar chart of indicator weights for commercial banks is shown in Figure 2.

The evaluation results obtained by the game theory method are consistent with those obtained by the entropy and hierarchical analysis methods. It has been proved that the game theory method is reasonable and feasible in determining the weight of indicators in the comprehensive evaluation of the green economy. The results of Table 2 show that the weights of financial, customer, employee, internal and external indicators are 0.374, 0.207, 0.050, 0.269, and 0.100, respectively, which indicate that for commercial banks, financial and customer indicators have a more significant influence on the green economy of commercial banks. Among the secondary indicators, the green credit ratio, cumulative green finance customers, green credit balance, the growth rate of green finance customers, and water conservation have high weights. It is indicated that green credit is the primary influence on the green economy of commercial banks, while improving green finance customers and water efficiency are also extremely important.

Table 2 Indicator weights

Tier 1 indicators	Entropy method	AHP	Game theory method	Secondary indicators	Entropy method	AHP	Game theory method
A	0.3896	0.3684	0.374	A1	0.025	0.027	0.026
				A2	0.033	0.040	0.038
				A3	0.035	0.044	0.042
				A4	0.052	0.067	0.063
				A5	0.143	0.108	0.117
				A6	0.103	0.081	0.087
B	0.1971	0.2105	0.207	B1	0.077	0.095	0.090
				B2	0.070	0.088	0.083
				B3	0.050	0.027	0.033
C	0.0431	0.0526	0.050	C1	0.012	0.039	0.032
				C2	0.031	0.013	0.018
D	0.2856	0.2632	0.269	D1	0.012	0.035	0.029
				D2	0.019	0.070	0.056
				D3	0.016	0.052	0.042
				D4	0.145	0.052	0.077
				D5	0.095	0.054	0.065
E	0.0845	0.1053	0.100	E1	0.039	0.042	0.041
				E2	0.045	0.063	0.058

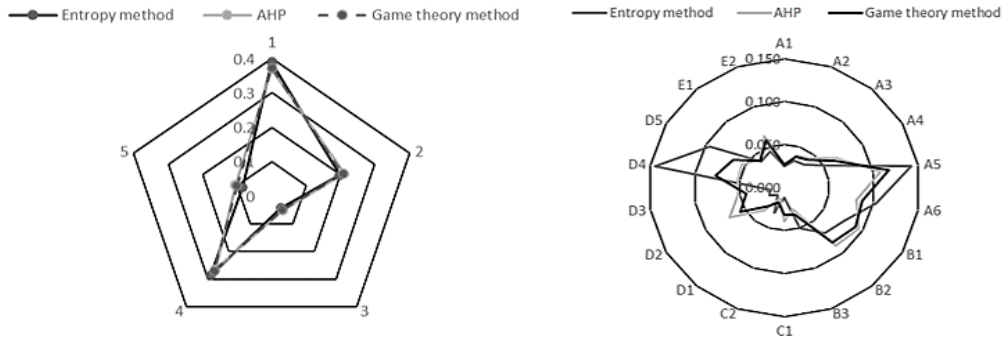

Figure 2 Radar chart of indicator weights for commercial banks

3.3 Green economy evaluation of commercial banks based on game theory-TOPSIS

After determining the degree of influence of each indicator on financial risk based on the integrated game theory assignment method, the TOPSIS model was applied to determine the ideal solution and negative ideal solution of each indicator and the relative closeness of each case bank to the ideal solution was determined by finding the Euclidean distance between each case company and the ideal solution and negative ideal solution. The case companies were ranked accordingly to determine the size ranking of their green economy index. The results of the calculations and rankings are shown in Table 3.

Table 3 TOPSIS results

Commercial Banks	Bank A	Bank B	Bank C	Bank D	Bank E	Bank F	Bank G	Bank H
d^+	0.1829	0.1203	0.2293	0.1776	0.1529	0.2001	0.2250	0.2250
d^-	0.1296	0.1981	0.0768	0.1403	0.1642	0.1113	0.0761	0.1101
D	0.4147	0.6221	0.2510	0.4414	0.5178	0.3573	0.2529	0.3285
D Ranking	4	1	8	3	2	5	7	6

From Table 3, the green economy indices of the eight commercial banks from 2016 to 2020 are ranked from largest to smallest: Bank B, Bank E, Bank D, Bank A, Bank F, Bank H, Bank G, and Bank C.

Bank B has the highest relative closeness to the ideal solution at 0.622, mainly due to its higher green credit ratio, green credit balance, and green finance customer growth rate. The relative closeness of Bank E to the ideal solution is 0.518, with Bank E ranking second and highly correlated with its higher cumulative green finance customer base. Bank D has a high growth rate of green finance customers and a high green credit ratio, with the third-highest relative closeness to the ideal solution at 0.441. Bank C has the lowest relative closeness to the ideal solution of 0.251. Bank C's green economy index is the smallest among the case banks because of the lower recognition of green culture by its employees and the lower intensity of government support.

4. Conclusions and Recommendations

This study evaluated the green economy of eight commercial banks using grey correlation analysis and game theory combined with weighting and TOPSIS methods. Looking at the correlations between the secondary indicators, there is a good correlation, with the proportion of green credit being the dominant factor. Meanwhile, combining entropy and hierarchical analysis, we found that they all contribute significantly to the evaluation of commercial banks' green economy, with the green credit ratio playing a crucial role. From the data, it is found that although there are still some problems with the green economy development of commercial banks. With their increasing attention to green economy development, the green economy development of commercial banks will have great potential in the future as long as they further increase their product innovation, vigorously cultivate green financial business talents, and make up for the shortcomings of relatively insufficient policy orientation.

Based on the above research analysis, the suggestions for the green economy improvement measures of commercial banks in China are as follows:

1. Increase product innovation

Commercial banks should innovate green financial products from both expanding existing areas and developing new areas, continuously improve the system of green financial products, strengthen the research and development of green financial products, and enhance the flexibility, applicability, and operability of green financial business,

2 Vigorously cultivate green financial business talents

The cultivation of green financial talents is the core guarantee for promoting the development of China's green economy and an inevitable requirement for the construction of green banks. Commercial banks in China should fully understand the importance of talents in green financial development, continuously strengthen the construction of green financial talents and cultivate comprehensive and professional green financial talents.

3 External safeguard measures

Relevant government departments should define the concept and scope of green finance more clearly and provide corresponding policy guidance to commercial banks on the green finance business. At the same time, the incentive policies for green finance is improved to encourage commercial banks to incline their resources towards green banking.

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