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Research on the Evaluation of Economic Responsibility Audit of State-Owned Enterprise Leaders from the Perspective of Green and Low Carbon

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Abstract. With the implementation of the "carbon peaking and carbon neutrality" target strategy, green, low-carbon development has become the main way of economic development, and the low-carbon economic operation and healthy development of state-owned enterprises not only play a leading role in the operation of the national economy as a whole, but also are economic entities that bear greater pressure for green and low-carbon development. This paper focuses on the construction of an evaluation system for the economic responsibility audit of the leaders of state-owned enterprises from a green and low-carbon perspective, using the hierarchical analysis method to determine the weights of each evaluation index, and selecting three commercial state-owned enterprises of Gansu province for verification. The evaluation system is feasible and contributes to the balanced development between the economic development of state-owned enterprises and green and low-carbon.

Keywords. green and low carbon; state-owned enterprises; economic responsibility audit; audit evaluation system

1. Introduction

Since the 1990s, China's economic responsibility audits have made great strides in development, with the successive introduction of relevant systems and regulations. The "Regulations on Economic Responsibility Audits of Major Leading Cadres of the Party and Government and Major Leaders of State-owned Enterprises and Institutions", revised in 2019, state that economic responsibility audits should implement the new development concept, promote high-quality economic development, facilitate comprehensive deepening of reform and promote modernization of the national governance system and governance capacity. In the report of the 20th Party Congress, it was stressed that the concept of "green water and green mountains are the silver mountain of gold" must be firmly established and practiced. Against the backdrop of the "double

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carbon" goal of achieving peak carbon and carbon neutrality, strengthening ecological environmental protection and actively responding to climate change with a view to reducing pollution and reducing carbon as a means to increase efficiency is the only way to build a "beautiful China" and achieve sustainable development for the Chinese nation Li and Fang（2023)[1] . State-owned and state-controlled enterprises are the "front-runners" in social and economic development, and are an important force in developing a green economy and building an ecological civilization Liang L. (2021)[2], Li Chao(2021)[3]. Therefore, proposes to reconstruct the evaluation system based on the existing evaluation system for the economic responsibility of leading cadres of state-owned enterprises, with emphasis on the need for full coverage and green and low-carbon development, using a commercial class of state-owned enterprises as an example and three entities in Gansu Province as a trial run.

2. Construction of an evaluation system for economic responsibility audits of state-owned enterprises in the commercial category

2.1. Research status of evaluation index construction

In the process of constructing the evaluation index of enterprise performance audit, different scholars adopt different methods, but they always follow the analysis principle of qualitative and quantitative merger. For example :Zheng Shiqiao (2018)[4] ,Wang Xiaohui（2006)[5],Li ZD, Guo L.（2022)[6]believes that the economic responsibility evaluation index system should be based on different industry characteristics and different types of cadres to select economic responsibility evaluation indicators. In the context of low-carbon economic development, Liu Xuan（2015[7]Zheng Guohong (2017)[8]Chen Yijin(2023)[9] used AHP to construct a comprehensive audit evaluation system for green economic responsibility of state-owned enterprises, mainly selecting indicators from three levels : sustainable development, production and operation, and social responsibility.

2.2.Construction of the evaluation system of commercial state-owned enterprises

The evaluation system for commercial state-owned enterprises is ② guided by the concepts of full audit coverage, "carbon peaking and carbon neutrality" strategy and green low-carbon development. Specifically, it includes: the guideline level, i.e. the primary indicators: return on capital and quality efficiency, marketability, internationalization, sustainability of economic development, and integrity and governance. Specifically, there are 5 first-level indicators, 13 second-level indicators and 47 third-level indicators.(see Table 3 for details).

② Based on the role, status quo and needs of SOEs in economic and social development, central enterprises are defined as commercial (including commercial category 1 and commercial category 2) and public welfare according to their main business and core business scope, including: commercial category 1 enterprises: focus on fully competitive industries and fields, improve the rate of return on state-owned assets, ensure product quality, and be a market-oriented, international and competitive leader. The enterprises in the commercial category are

3. Calculation and application of the weights of the economic responsibility audit evaluation indicators

3.1.Determination of the weighting of audit evaluation indicators

This paper applies the hierarchical analysis method (AHP) to determine the weights of economic responsibility audit evaluation indicators for a commercial category of state-owned enterprises.

3.1.1 Modelling the hierarchy. Objective level: Evaluation index system for economic responsibility audits of commercial category 1 state-owned enterprises.

Criteria level: The five dimensions of return on capital and quality and efficiency, marketability, internationalization, sustainability of economic development and integrity are set out in 13 levels, all of which are positive indicators, B1, B2, B3,...,B13 respectively. Indicator layer: 47 items in total, of which 42 are positive indicators, 5 are negative indicators and 3 are qualitative indicators. These are C1,C2,C3,...,C47. See Table 2:

3.1.2 Construction of the judgment matrix.

The construction of the judgment matrix starts from the 2nd layer of the hierarchical model, and the indicators in the same layer are compared two by two from top to bottom layer by layer to obtain the judgment matrix B = (b_{ij})n*n, b_{ij} denotes the relative weight values of elements i and j in a layer and the elements in the previous layer, i.e. the values obtained by comparing the two elements of i and j. n denotes the number of elements, then the calculation formula of the judgment matrix A is as follows: B = (b_{ij})n*n
The matrix is characterized as follows: b_{ij} >0 b_{ij} =1/b_{ij} b_{ij} =1
Taking the profitability of the elements of the secondary indicator B1 as an example, by constructing a judgment matrix of the above elements that are comparable between two elements and using the metrics to give the corresponding weights to each element, such as the judgment matrix constructed for the B1 criterion level and the indicator level below B1 is shown in Table 1[③] :

Table 1. B1 Judgement matrix constructed at the criterion level and the corresponding indicator level

B1	C1	C2	C3	C4	C5	Wi
C1	1.0000	0.2500	0.3333	0.2500	0.2000	0.0554
C2	4.0000	1.0000	2.0000	1.0000	0.3333	0.2018
C3	3.0000	0.5000	1.0000	1.0000	0.3333	0.1444
C4	4.0000	1.0000	1.0000	1.0000	0.5000	0.1905
C5	5.0000	3.0000	3.0000	2.0000	1.0000	0.4079

3.1.3.Consistency test and calculation of criterion layer weights.

The following is an example of the process of calculating the weights for the profitability profile B1 at the return on capital and quality return levels:① The product of the values

[③] The data in the table indicates which of the two elements below B1, Ci or Cj, is more important and influential, on a scale of 1 to 9. The degree of influence bij, which indicates Ci and Cj on B1, is quantified by assigning values.

of the elements of each row of matrix A yields M_i . i.e. calculate the geometric mean of the factors in each row $M = {}_i \prod a_{ij}$, i = 1, 2, ..., n, to obtain $M_1 = 0.0042$, $M_2 = 0.6666$, $M_3 = 0.1667$, $M_4 = 0.5$ and $M_5 = 18$.②Calculate the nth root of M_i to obtain $W = {}_i\sqrt[n]{Mi}$. Calculate the 5th root of M_i , i.e. $Wi=\sqrt[n]{Mi}$, i = 1, 2, ..., n, to obtain $W_1 = 0.3342$,$W_2 = 0.9221$,$W_3 = 0.6988$,$W_4 = 0.8706$,$W_5 = 1.7826$.③Normalize the vector to obtain $W_i = M /{}_i\sum_{j=1}^{n} Mj$. W1 = 0.0554, W2 = 0.2018, W3 = 0.1444, W4 = 0.1905 and W5 = 0.4079 were calculated, i.e. the resulting eigenvector is W = (0.0554, 0.2018, 0.1444, 0.1905, 0.4079).④ Calculate the maximum eigenvalue $\lambda \max = \frac{1}{n}\sum_{i=1}^{n} \frac{(B_1W)_i}{W_I}$. This yields λ max = 5.1160.⑤Consistency test, using the random consistency ratio CR to determine whether the matrix has a head and tail consistency, the test standard is : CR = CI / RI. If CR ≥ 0.1, the judgment matrix is chaotic and lacks consistency, and the elements of the judgment matrix need to be adjusted. If CR < 0.1, the judgment matrix is consistent. By calculating the CR values of each index are less than 0.1, as shown in the table 2. All pass the consistency test, and the obtained weight results are reasonable and can be used.

Table 2.CR value of each evaluation index

Indicators	Target level	(B1)	(B2)	(B3)	(B4)	(B5)	(B6)
CR	0.0517	0.029	0.0629	0.0092	0.0274	0.0274	0.0001
Indicators	(B7)	(B8)	(B9)	(B10)	(B11)	(B12)	(B13)
CR	0.0437	0.0001	0.0001	0.0001	0.0001	0.0239	0.0072

Based on the above calculation steps, the AHP software was used to calculate the weights of each criterion layer and the corresponding indicator layer one by one. See Table 3:

Table 3. Evaluation index system and weights for economic responsibility audits

Target level	Guideline level				Indicator layer	Weighting
	Tier 1 indicators		Secondary indicators		Tertiary indicators	
Economic responsibility audit evaluation index system for commercial category 1 state-owned enterprises 100%	Return on capital and quality gains	24%	Profitability (B1)	9.88 %	Return on Net Assets ($C_{1,1}$)	0.55%
					Return on Total Assets ($C_{1,2}$)	1.99%
					Surplus cash cover multiple ($C_{1,3}$)	1.43%
					Cost Margin ($C_{1,4}$)	1.88%
					Rate of return on capital ($C_{1,5}$)	4.03%
			Asset quality (B2)	7.91 %	Total Asset Turnover ($C_{2,1}$)	1.82%
					Inventory turnover rate ($C_{2,2}$)	0.37%
					Accounts receivable turnover rate ($C_{2,3}$)	2.17%
					Non-performing assets ratio ($C_{2,4}$)	1.15%
					Cash recovery rate on assets ($C_{2,5}$)	2.40%
			Debt risk (B3)	4.31 %	Gearing ratio ($C_{3,1}$)	0.92%
					Interest earned multiplier ($C_{3,2}$)	0.40%
					Current ratio ($C_{3,3}$)	0.25%

					Quick Ratio ($C_{3,4}$)	0.85%
					Cash flow liability ratio ($C_{3,5}$)	1.89%
			Operational growth (B4)	1.90 %	Sales (operating) growth rate ($C_{4,1}$)	0.09%
					Capital preservation and appreciation rate ($C_{4,2}$)	0.44%
					Sales (operating) profit growth rate ($C_{4,3}$)	0.72%
					Growth rate of total assets ($C_{4,4}$)	0.42%
					Technology input ratio ($C_{4,5}$)	0.23%
	Level of marketability	11.12%	Degree of market openness (B5)	4.69 %	Market-based employment levels (qualitative) ($C_{5,1}$)	0.48%
					Employee shareholding ratio ($C_{5,2}$)	0.81%
					Amount of dividends ($C_{5,3}$)	3.40%
			Degree of market development (B6)	2.73 %	Extent to which an enterprise's internal market-based management system is well developed (qualitative) ($C_{6,1}$)	1.36%
					The degree of adequacy of internal supporting departmental regulations (qualitative) ($C_{6,2}$)	1.36%
			Market share (B7)	3.70 %	Overall market share ($C_{7,1}$)	0.22%
					Target market share ($C_{7,2}$)	0.69%
					Relative market share ($C_{7,3}$)	1.02%
					Comparative market share ($C_{7,4}$)	1.77%
	Internationalization level	17.42%	Inward-looking internationalisation (B8)	3.55 %	Ratio of foreign purchases to total purchases ($C_{8,1}$)	1.18%
					Ratio of foreign investment attracted to total investment ($C_{8,2}$)	2.37%
			Outward-looking internationalisation (B9)	6.09 %	Ratio of foreign investment to total investment ($C_{9,1}$)	2.03%
					Foreign sales to total sales ratio ($C_{9,2}$)	4.06%
			Invisible Internationalisation (B10)	7.78 %	"One Belt, One Road" exchange ($C_{10,1}$)	2.59%
					Outbound investment profile ($C_{10,2}$)	5.19%
	Economic development sustainability	36.41%	Social contribution (B11)	17.59 %	Social contribution rate ($C_{11,1}$)	5.86%
					Employment contribution rate ($C_{11,2}$)	11.73 %
			Environmental	18.82 %	Carbon emission rate ($C_{12,1}$)	2.74%

			protecti on and resource use (B12)		Ecosystem restoration rate ($C_{12,2}$)	1.82%
					Rate of treatment of "three wastes" ($C_{12,3}$)	1.79%
					Environmental profit and loss lift rate ($C_{12,4}$)	1.86%
					Rate of reduction in energy consumption per unit of GDP ($C_{12,5}$)	3.53%
					Rate of reduction in resource consumption ($C_{12,6}$)	3.45%
					Rate of conversion of scientific and technological achievements ($C_{12,7}$)	3.63%
	Integrity in Politics	11.0 5%	Integrit y in Politics (B13)	11.05 %	Penalty expenditure rate ($C_{13,1}$)	1.30%
					Personal Illicit Income Rate ($C_{13,2}$)	3.51%
					Average annual duty consumption ratio ($C_{13,3}$)	6.24%

3.2.Application of evaluation indicator system

3.2.1.Data collection.

Quantitative indicators data were obtained from Gansu Province A, B and C[④] Financial data of three commercial category 1 listed state-owned enterprises for 2019-2021 were compiled and summarized by hand. Qualitative indicators are transformed into quantitative data through the standardization of data, based on the ideas and application of the fuzzy mathematical affiliation theory of L.A. Zadeh (1965), Professor of Cybernetics at the University of California, USA.

3.2.2.Evaluation Indicator Normalization Processing.

The raw data values were normalized to keep the results within [0, 1]. Firstly, a distinction is made between very large and very small indicators of their own nature, and secondly, the indicators are calculated based on the formula:

Very Large Indicators: $x_{ij} = \frac{u_{ij}}{uj_{\max}}$ Very Small Indicators: $x_{ij} = \frac{uj^{\min}}{u_{ij}}$

[④] As it relates to the financial information of the business, A, B and C are used instead of the company name.

3.2.3.Hierarchical analysis Evaluation.

According to the classification of target level, criterion level (including primary and secondary indicators), indicator level (including tertiary indicators) and the calculated weights in Table 2, and combined with the collected data of specific indicators, the state values of each level Z, B_i , C_{ij} are calculated by the formula: $Z= \sum \text{Factor status value} \times weighted$.First, the score of the criterion level (secondary indicator) is calculated, $B_i= \sum \text{Level 3 indicator status values Cij}^{⑤} \times \text{Three} - \text{level indicator weights Wi}$, and the calculation results are shown in Table 3 for B1..., B13.Next, the target layer score was calculated, $Z= \sum \text{Bi} \times \text{Benchmark layer secondary indicator weights di}$, and the calculation results are shown in Table 4 for Z values.

Table 4. Table of comprehensive evaluation results

Company A	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	Z
	0.042	0.008	0.210	-1.972	0.009	0.512	0.205	0.139	0.108	0.597	-0.009	0.337	0.000	0.082
Enterprise B	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	Z
	0.056	0.115	0.148	0.469	0.001	0.270	0.079	0.041	0.038	0.360	0.008	0.000	0.000	0.073
Enterprise C	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	Z
	0.062	0.116	0.264	0.205	0.003	0.544	0.414	0.101	0.084	0.363	0.009	0.010	0.000	0.100

3.2.4.Evaluation and analysis of the results.

According to the evaluation and analysis results of the three enterprises, the evaluation values of enterprises A, B and C are 0.082, 0.073 and 0.100 respectively, with C > A > B, indicating that enterprise C has the best performance in fulfilling its economic responsibility, followed by enterprise A and the worst by enterprise B. From the primary indicators, it is clear that enterprises A, B and C are all performing well in terms of their economic responsibilities in terms of integrity and meet the compliance objectives of the economic responsibility audit.

A more specific analysis reveals that Enterprise C ranks first among the three enterprises in terms of economic responsibility performance in the three areas of return on capital and quality of earnings, marketability and social contribution at the level of primary indicators. Looking specifically at the secondary indicators, it is found that the performance of economic responsibility fulfillment needs to be further improved in the areas of operational growth, market openness, internationalization, environmental protection and resource utilization. Company A is the strongest in terms of internationalization, environmental protection and resource utilization, but the weakest in terms of social contribution. Company C is the best overall, particularly in terms of quality of operations, market openness, internationalization and social contribution, but is clearly weaker in terms of environmental protection and resource utilization.

⑤ Collecting and researching data

4.Conclusions and recommendations

The above study shows that focusing on the green and low-carbon dimension in the economic responsibility audit of leading cadres of state-owned enterprises will definitely help to enhance the environmental awareness of enterprises and balance between enterprise development and low carbon, thus helping to achieve the "double carbon" goal of China rapidly. We suggest: Firstly, green, low-carbon development requires a lot of investment upfront, and in order to sort out good low-carbon development concepts in enterprises, governments at all levels need to make more development policies and financial investments to encourage this, while strengthening economic responsibility audit evaluation. Second, the government should guide enterprises to establish low-carbon development funds, especially for enterprises with good economic development, and encourage a good balance between economic development and low carbon.

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