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Comprehensive Evaluation Model Construction of Multidimensional Financial Indicators Based on Entropy Weight Method

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ABSTRACT
The rapid development of the economy in recent years has brought convenience to enterprises, but also made the competition between enterprises more intense, enterprises want to stand firm in the fierce competition not only to improve financial performance, but also from a multi-dimensional integrated perspective. For this reason, this paper launched a multidimensional financial comprehensive evaluation research for enterprises. Based on the Harvard analytical framework, the study firstly emphasizes the financial performance of enterprises and at the same time combines the social responsibility perspective to screen the indicators. Then the quantitative evaluation method of this paper is proposed, i.e. the entropy weight method and gray correlation method are combined to analyze the development status of multidimensional financial performance from an objective point of view. Then the entropy weight method and gray correlation method model are introduced respectively, and the modeling method of combining the two applied in this paper is explained. Finally, by analyzing and evaluating the results of the sample company M, it can be obtained that (1) the results of the correlation degree of company M from 2017 to 2022 are 0.722, 0.473, 0.398, 0.389, 0.426, and 0.496 respectively, and the results of the multidimensional financial synthesis evaluation of company M during these six years are optimal in 2017. (2) The overall performance of the financial capital status of Company M from 2017 to 2022 is gradually deteriorating. (3) Overall, the performance of Company M's responsibility to its employees is evolving from 2017 to 2022. (4) The company's performance of responsibility to consumers and government during the six years from 2017 to 2022 is good, but ecological responsibility is at a medium level and has some room for development. This paper provides a multidimensional and comprehensive evaluation of the financial indicators of the company from a scientific point of view, which provides some reference for investors and business managers.

Keywords: Harvard analysis framework; social responsibility; entropy weight method; gray correlation; comprehensive financial evaluation

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1. Introduction

The financial evaluation of the project is the primary criterion for the analysis of decision-making for the implementation of new projects. Financial evaluation is to measure the value of the project's financial indicators through calculation, according to which the project's economic benefits and operating costs are predicted and analyzed [1-2]. For the project profitability, operation, solvency and other financial indicators, the most intuitive reflection of the actual situation of the project's capabilities, is conducive to the management and decision makers to more fully understand the project, accurately determine the feasibility of the project [3-5]. This requires continuous improvement and refinement of the project financial evaluation index system, the formation of a more scientific, effective, reasonable and accurate index system, so that it can be more complete and comprehensive reflection of the enterprise's profitability, solvency, operation and development and other capabilities.

The traditional evaluation system focuses on the "quantity" and "speed" of enterprise development, while the high-quality development evaluation system should pay more attention to the "quality" and "efficiency" of development, and fully demonstrate the characteristics of high-quality development after economic reform [6-7]. The new financial evaluation system should give full play to the objective evaluation role of financial indicators under the conditions of high-quality development, guide enterprises to strengthen the new development concept, set up a scientific view of development, effectively break the stereotypes of thinking, work inertia and path dependence, and realize a higher-quality, more efficient, and more sustainable high-quality development with the new changes in the ideological concepts, new expansions in the work ideas, and new breakthroughs in the development paths [8-11].

Entropy weight method mainly refers to a method of obtaining the weights of indicators through objective assignment, which is widely used in engineering technology and socio-economic and other related fields [12-14]. Through the entropy weighting method, it can be concluded that the smaller the entropy value of an indicator is, the more information the indicator provides, so it plays a greater role in the comprehensive evaluation, and its weight is also greater [15-17]. On the contrary, it means that the indicator provides less information, and thus plays a smaller role in the comprehensive evaluation, and its weight is also smaller.

Literature [18] constructed an enterprise risk financial data prediction index system based on the entropy weight method, input data with higher weights of risk indicators into the neural network, and constructed an enterprise financial risk prediction model with high prediction accuracy by calculating the weights of risk data nodes at different levels of the network. Literature [19] proposed a multi-criteria decision-making model (MCDM) to analyze the causal relationship of financial ratios on corporate financial performance based on the entropy weight method and TOPSIS model, and found that debt-equity ratio (DER), return on equity (ROE) and current ratio (CR) have the greatest impact on corporate financial performance. Literature [20] introduces the fuzzy reference ranking technique on the basis of entropy weight method-TOPSIS model, which strengthens the extraction of valuable information in the financial ratios due to the fuzzy concepts that help to reduce ambiguity and helps to study the impact of corporate financial ratios on corporate financial performance, and further provides assistance in the assessment of corporate financial performance. Literature [21] discusses how to build the financial risk evaluation system of Shanxi Fenjiu enterprise from four perspectives of profitability, operating ability, solvency and development ability, and adopts the entropy weight TOPSIS method to develop a set of reasonable financial management plan for the enterprise, which can solve the enterprise's financial risk from the root and enhance the financial value. Literature [22] examined the application of MCDM model with integrated entropy-fuzzy VIKOR method in the financial performance evaluation of listed construction enterprises, which determines the prioritization and ranking of the financial ratios of the construction enterprises, and is able to better reflect the financial performance of the construction enterprises. Literature [23] calculates the weights

of the aggregated financial ratios through the principle of maximum entropy and constructs a financial performance assessment model aiming at an objective and unbiased analysis of the financial situation of the Bank of Brazil, which demonstrates that the assessment of the financial performance based on the proposed methodology plays an important role in supporting the enterprises to formulate the issues of portfolio optimization, resource allocation and credit analysis.

Starting from a multidimensional perspective, this paper adopts the Harvard analysis framework to construct evaluation indicators consisting of five target layers, including financial capital, human capital, market social capital, social capital and ecological capital, from the perspective of corporate social responsibility, and uses entropy weighting and gray correlation to determine the weights given to the indicators and to establish a comprehensive evaluation model of multidimensional financial indicators. This paper links practice and theory, takes M Company as a sample company, analyzes the financial data of the enterprise in the past six years, and analyzes the evaluation results, and provides suggestions and references in strengthening the fulfillment of corporate social responsibility and improving the financial performance of the enterprise, so as to realize the enterprise to achieve sustainable development.

2. Financial theory based on the Harvard analytical framework and the social responsibility perspective

2.1. Harvard Theory of Analytic Framing

The Harvard Analytical Framework is a financial diagnosis from four perspectives, namely, strategic analysis, accounting analysis, financial analysis and prospect analysis, which mainly provides enterprises with a more comprehensive and comprehensive analysis of their financial situation and prospect forecasts. The four perspectives under the Harvard Analytical Framework start from different focuses but have common links, and the perspectives are complementary and mutually reinforcing. The Harvard Analytical Framework takes into full consideration the external and internal environment of the enterprise, effectively combines enterprise activities and financial reporting, and makes up for the limitations of the general financial analysis process.

Harvard analysis framework, as shown in Figure 1, is mainly through the analysis of the industry environment in which the enterprise is located, including the external and internal environments, as well as the strategy adopted for itself, and then make reasonable judgments on the enterprise's financial reporting, and the main content of its analysis includes four aspects, namely, strategic analysis, accounting analysis, financial analysis, and prospect analysis. This paper summarizes these four aspects into a complete process framework diagram.

Strategic analysis is to analyze the enterprise from its overall perspective, which influences the future development direction of the enterprise and serves to help the enterprise achieve its ultimate goal. Strategic analysis is the starting point for enterprise financial diagnosis, which requires the diagnostician to comprehensively grasp the financial and operational situation from the overall perspective of the enterprise, so as to formulate a strategic planning in line with the development of the enterprise. Strategic analysis of the enterprise can provide a perspective for the stakeholders to have a fuller understanding and awareness of the enterprise, and can fully understand the enterprise's development goals, development planning and the development prospects of the industry.

The validity of the results of financial statement analysis depends largely on the authenticity of the accounting information disclosed by the enterprise, that is, the reliability of the data in the enterprise's financial statements. Accounting analysis is an indispensable part of enterprise financial analysis and financial diagnosis, and the analysis should focus on analyzing the appropriateness of the enterprise's application of accounting and financial management principles and the enterprise's flexibility in accounting treatment. From the point of view of the function of the use of accounting analysis, it can effectively improve the efficiency of the users of financial statements, in order to ensure the

authenticity and accuracy of the financial statements under the premise of improving the workers to grasp the degree of enterprise financial information and data, so as to ensure that the accounting analysis of the work of the smooth progress of the work.

The essence of financial analysis is to analyze the financial statements of the enterprise's daily operation and management activities, and the main content is the predictive analysis of the enterprise's profitability, solvency, operating ability and development ability. Financial analysis under the Harvard Analytic Framework not only focuses on the financial data of the enterprise, but also analyzes the industry environment in which the enterprise is located as well as the reasons for the anomalies of its financial data in the process of development.

Prospective analysis, that is, the enterprise in the development of the same time, also need to focus on the future prospects and direction of development, can not only focus on the immediate interests and ignore the future sustainable development of the enterprise. The development prospects of the enterprise relates to the future of the enterprise, investors are concerned about the main issue is whether the enterprise can be sustainable development, can always maintain a good development situation in the industry.

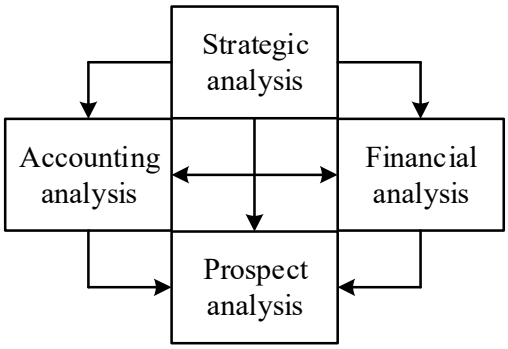

Fig. 1. Harvard analysis frame diagram

2.2. Multidimensional financial indicators from the perspective of social responsibility

Corporate social responsibility refers to the enterprise's pursuit of maximum profit in the process of production and operation, maximize the protection of the interests of shareholders, and also need to fulfill obligations to other stakeholders. This paper combines the relevant indicators of corporate social responsibility status with the Harvard analytical framework, comprehensively considers the reality of corporate financial performance, and evaluates the financial performance indicators achieved by the business activities of enterprises from the perspective of corporate social responsibility.

Stakeholder theory is stakeholder at that time refers to the fact that the survival and sustainability of the enterprise must have the common support of different members such as shareholders, employees, customers, creditors, suppliers and social responsibility.

Motivation refers to the psychological drive, in management work is how to mobilize people's enthusiasm, containing motivation, encourage behavior, form motivation, maintain human behavior, and so on, so as to guide individuals to achieve organizational goals. Motivation theory, as shown in Figure 2, believes that people have different needs in different aspects, which can be divided into physiological needs, spiritual needs, and self-actualization needs and so on. Subsequently, cognitive and aesthetic needs and later transcendent needs were added, expanding the five-stage model to an eight-stage one. Under the background of this theory, enterprises need to set incentive policies to the overall goals of the enterprise and the development of individual employees into the same plan, the link between employee development and enterprise performance needs to be closer, only employees work hard to achieve the performance requirements of the employee's personal goals can be realized.

Considering that this paper evaluates the financial performance of the enterprise based on the perspective of social responsibility, which mainly reflects the financial performance of the enterprise, this paper divides the stakeholders into financial capital, human capital, market social capital, hierarchical social capital and eco-capital as the target layer on the basis of the above theories. Finally, according to each stakeholder to select the corresponding evaluation indexes that can properly reflect the financial performance of the enterprise, due to consider the practicality of the evaluation system, the selected indexes should be in line with the development of the times, in the selection of indexes, this paper will select the index data that is compatible with the development of society as the evaluation indexes of the evaluation system.

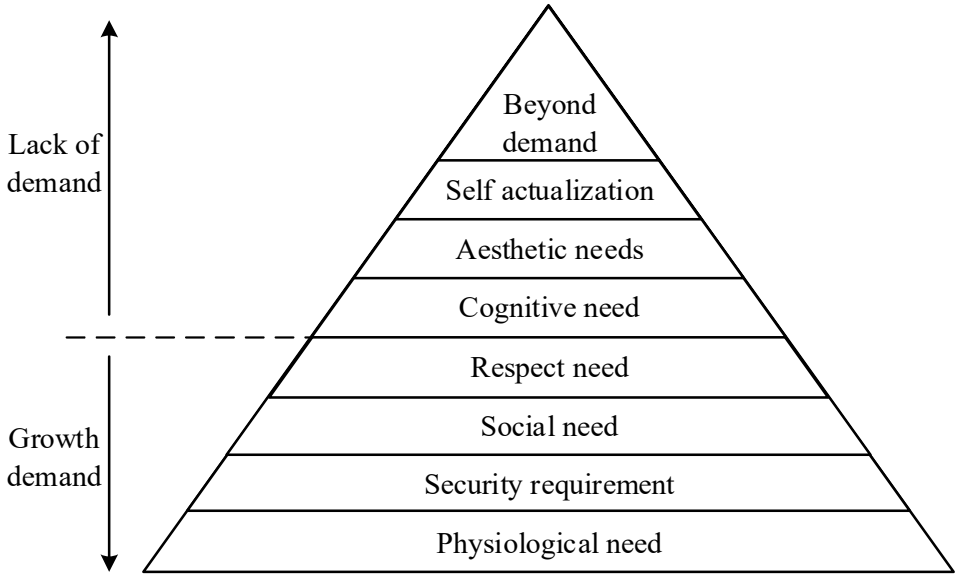

Fig. 2. Maslow's excitation model

3. Construction of multi-dimensional financial index evaluation system based on entropy weight method

3.1. Evaluation model construction based on entropy weight method and gray correlation degree

3.1.1. Modeling of the entropy weighting approach. Entropy weight method is a diversified statistical method, which is usually used to evaluate comprehensive indicators. In this paper, eight indicators are selected in the evaluation of financial performance of listed companies in the port, and the weights of the indicator data are determined by entropy weight method, which is divided into the steps of dimensionlessness, calculation of information entropy, and determination of weights as follows:

Step 1 Indicator dimensionlessization:

Dimensionless refers to the expression that the physical derived quantity is expressed as the product of the multiplication of a number of basic quantities, while dimensionless refers to the expression form after applying a suitable quantity instead of removing the unit of each data, the index dimensionless not only simplifies the calculation process but also makes it possible to calculate some physical quantities that the samples can't be directly compared directly. The formula for dimensionlessness is:

$$Y_{ij} = \frac{x_{ij} - \min(x_i)}{\max(X_i) - \min(x_i)} \tag{1}$$

The meaning expressed by the formula is: calculate the weight of the preprocessed value under the jnd indicator of the ist evaluation indicator object to the sum of all values under that indicator, assuming that k indicators are given $X_1, X_2, ..., X_n$, where $X_i = \{x_1, x_2, \cdots\cdots, x_k\}$. Assuming that the value obtained by dimensionless quantization of the data of each indicator is $Y_1, Y_2, \cdots\cdots, Y_k$, thus forming a sequence of dimensionless quantization indicators.

Entropy is a concept from thermodynamics, which is used to measure the degree of intermolecular chaos, and the role of information is used to help people to confirm the uncertainty step by step, so the thermal entropy and the information entropy are two relative although, combined with the definition of the information entropy and mathematical calculations can be obtained by calculating the entropy of the jth indicator.

Step 2 Solve the information entropy of each indicator:

$$E_j = -\ln(n)^{-1} \sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{2}$$

where $p_{ij} = \sum_{i=1}^{n} Y_{ij}$, if $p_{ij} = 0$ occurs, is defined:

$$\lim_{p_{ij} \to 0} p_{ij} \ln p_{ij} = 0 \tag{3}$$

Step 3 Determine the weight value of each indicator:

According to the formula of information entropy, so as to calculate the information entropy of each indicator $\varepsilon_1, \varepsilon_2, \cdots\cdots, \varepsilon_k$. According to the information on the formula for calculating the weight of each indicator is:

$$W_i = \frac{1 - E_i}{k - \sum E_i} (i = 1, 2, ..., k) \tag{4}$$

3.1.2. Gray correlation method modeling. The idea of gray correlation analysis method is that among many objective things and factors, the interrelationships are complicated, and people cannot get comprehensive and sufficient information to form a clear concept when they recognize, analyze and make decisions. When the gray correlation is calculated, the similarity of the geometric shape of the sequence is used to determine whether the connection between the data is close, if the curve is closer to indicate that the correlation between the corresponding sequences is greater, and vice versa, the smaller. Regarding the establishment of the model of gray correlation analysis method, it is divided into the following steps:

Step 1 Data processing:

The quantitative value of the evaluation indexes is processed dimensionless, which is mainly because for the indexes with different explicit outlines, they should be transformed into dimensionless data in order to facilitate the comparison, and there are two main methods for it.

Initialization:

$$x_i(k) = \frac{x_{i(k)}}{x_{i(l)}} \tag{5}$$

Initialization is usually used for time series data or economic series data.

Averaging:

$$X_{i(k)} = \frac{x_{i(k)}}{\overline{x}_i} \tag{6}$$

Where, $\overline{x}_i = \frac{1}{n}\sum_{k=1}^{n} X_{i(k)}$. Homogenization is used in most cases to do the data of the sampling series, so generally homogenization is chosen to dimensionless the sample indicators, the process is as follows:

Suppose a system has a parent factor of Y and m sub-factors, which are denoted as $X_i(i=1,2,...,m)$.

Assuming that n points have been obtained, the observed data for parent factor Y and subfactor $X_i(i=1,2,...,m)$ are as follows:

$$\begin{matrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \\ y_1 & y_2 & \cdots & y_n \end{matrix} \tag{7}$$

By reprocessing the above data and introducing new notation, it can be expressed as:

$$x_1^{(0)}(k) = \frac{x_{1k}}{\overline{x}_1}, k = 1,2,...,n \tag{8}$$

$$x_2^{(0)}(k) = \frac{x_{2k}}{\overline{x}_2}, k = 1,2,...,n \tag{9}$$

$$x_m^{(0)}(k) = \frac{x_{mk}}{\overline{x}_m}, k = 1,2,...,n \tag{10}$$

$$\begin{aligned} X_1 &= \left\{x_1^{(0)}(1), x_1^{(0)}(2), ..., x_1^{(0)}(n)\right\} \\ X_2 &= \left\{x_2^{(0)}(1), x_2^{(0)}(2), ..., x_2^{(0)}(n)\right\} \\ &\cdots \\ X_m &= \left\{x_m^{(0)}(1), x_m^{(0)}(2), ..., x_m^{(0)}(n)\right\} \end{aligned} \tag{11}$$

This process achieves the dimensionless processing of the sample data, which is carried out in order to compare and analyze them, due to the fact that in the actual data, the data of different factors have different scales.

Similarly, the n data for the parent factor Y need to be homogenized to obtain a sequence, denoted as:

$$X_0 = \left\{x_0^{(0)}(1), x_0^{(0)}(2), ..., x_0^{(0)}(n)\right\} \tag{12}$$

Where $x_0^{(0)}(k) = y_k / \overline{Y}, k = 1,2,...,n$, $\overline{Y}$ is the mean of n observations of the parent factor.

Step 2 Find the gray correlation $\xi(X_i)$ between the reference and comparison data columns:

The degree of correlation can be visualized by the degree of difference between the geometrical shapes, so that the difference between the curves can be used to measure the actual degree of correlation. A reference series X. There are many comparative series involved, e.g., $X_1, X_2, \ldots, X_n$, etc., so the correlation coefficient $£(X_i)$ should be determined on the basis of the different moments in the two sides, and the following formula can be obtained, with P representing the discrimination coefficient, which is basically kept in the range of 0-1, and more commonly set at 0.5.

In summary, the simplified processing results of the correlation coefficient derivative $\xi(X_i)$ can be derived, namely:

$$\xi_{i(k)} = \frac{\min_i \min_k |x_{o(k)} - x_{i(k)}| + \rho \max_i \max_k |x_{0(k)} - x_{i(k)}|}{|x_{o(k)} - x_{i(k)}| + \rho \max_i \max_k |x_{0(k)} - x_{i(k)}|} \tag{13}$$

Step 3 Finding the degree of association r_i:

Correlation is a physical measure of the degree of association between things and factors. Each data X_0 in the reference series has a correlation coefficient with X_i in the comparison series, and there are n in total, which results in the dispersion of the correlation coefficients of the whole indicator. So the degree of association is to solve this problem, it will be the use of each indicator corresponding to the correlation relationship, the systematic integration of a certain determined comprehensive value, this value is known as the degree of association, usually expressed in r, specifically expressed as:

$$r_i = \frac{1}{N} \sum_{k=1}^{N} \xi_i(k) \tag{14}$$

In the formula, r_i is the gray correlation of x_i with respect to the reference series x_0.

If the value of r_i is closer to 1, then it represents a higher correlation in the whole equation, as well as a closer match between the company's metrics and the best quality.

3.2. Evaluation model of entropy weight method and gray correlation

In this paper, in the multidimensional financial comprehensive evaluation, the entropy weight method and gray correlation degree method are combined to carry out performance evaluation, the specific practices are as follows:

Step 1 to the sample index data for the dimensionless processing, so that each index value in the sample represents the same meaning, so as to achieve the effect of de-unitization, so that all the sample data can be compared, calculated, analyzed.

Step 2 will sample the data after the dimensionless processing of information entropy calculation, solve the information entropy of each indicator, the information incentive value range is [0, 1], that is, to find out the degree of each indicator close to the optimal value, the closer it is to 1 means that its performance is better.

Step 3 will be the sample data information entropy series to find out the weight of each indicator, the weight represents for the entire evaluation system, each indicator accounts for the weight value of the entire indicator system, on behalf of the greater its impact on the overall performance evaluation results.

Step 4 will be the dimensionless processing of the data, to find out the correlation coefficient value series between the sample data.

Step 5 multiply the correlation coefficient value obtained by the gray correlation method with the weight coefficient value obtained by the entropy weight method to obtain the correlation value based on the weight coefficient, so as to carry out the ranking analysis, and the correlation calculation formula is:

$$\phi_i = \sum_{i=1}^{k} \frac{\min_i \min_k \left|x_{o(k)} - x_{i(k)}\right| + \rho \max_i \max_k \left|x_{o(k)} - x_{i(k)}\right|}{\left|x_{o(k)} - x_{i(k)}\right| + \rho \max_i \max_k \left|x_{0(k)} - x_{i(k)}\right|} \times \frac{1 - E_i}{k - \sum E_i} \tag{15}$$

3.3. Multi-dimensional Financial Comprehensive Evaluation Indicator Construction

In order to select evaluation indexes more rigorously and scientifically, this paper firstly summarizes 55 important indexes selected by relevant scholars on the evaluation of corporate financial performance based on social responsibility by reviewing and collecting relevant authoritative literature on social responsibility and corporate financial performance evaluation from 2011 to 2022, as well as the index data in the Standard Values for Corporate Performance Evaluation of the State-owned Assets Supervision and Administration Commission (SASAC). The number of evaluation

indicators is relatively large, and they can all reflect the social responsibility of enterprises to a certain extent. However, there are problems in these indicators such as difficult to quantify, data are not easy to obtain, and secondly, some indicators are not universal. Therefore, when selecting indicators, they should be combined with the actual situation of enterprises, and those that can reflect the fulfillment of corporate social responsibility, as well as those that are accessible and quantifiable, should be chosen.

In summary, this paper is based on the principle of comprehensiveness, scientificity, feasibility and systematicity of indicator selection, considering the accessibility and quantifiability of indicators, and combining with the actual situation of enterprises, the above summarized indicators are further decluttered, at the same time, and a number of theoretical and practical aspects of the expert interviews, according to the frequency of the application of the initial selection of indicators in the enterprise, the feasibility of practical operation and the ability to reflect the financial performance of enterprises and other aspects of screening recommendations. Can reflect the financial performance of enterprises and other aspects of the screening recommendations, through the statistical organization of expert recommendations, the final paper screened out 18 indicators, and then use the entropy weighting method to calculate the entropy value, the difference coefficient and get the weight, multi-dimensional financial comprehensive evaluation index system as shown in Table 1. Among them, the target layer (A) is divided into financial capital, human capital, market social capital, social capital and ecological capital. The guideline layer (B) is composed of eight indicators such as shareholders, creditors, employees, suppliers, consumers, government, society and environment. The Indicator Layer (C) under it contains 18 indicators such as total net asset margin, total asset turnover, sales profit margin, dividend payout ratio, gearing ratio, quick-frozen ratio, interest coverage multiple, employee salary growth rate, employee benefit ratio, safe production expense ratio, executive salary growth rate, accounts payable turnover ratio, R&D investment ratio, sales growth rate, tax revenue growth rate, employment growth rate, donations ratio, and packaging raw material consumption The 18 indicators are labeled as C1~C18. In terms of indicator weights, sales growth rate (0.1710), accounts payable turnover rate (0.1390), and executive salary growth rate (0.1381) are the three indicators with the highest weights.

Table 1. Multidimensional financial comprehensive evaluation index system

Target layer A	Criterion layer B	Index C	Entropy	Coefficient of difference	Weighting
Financial capital	Shareholders	Total net profit rate	0.8087	0.1914	0.0271
		Total asset turnover	0.5577	0.4424	0.0720
		Sales margin	0.877	0.1231	0.0145
		Dividend payment rate	0.82195	0.1782	0.0247
	Creditors	Asset ratio	0.6963	0.3038	0.0476
		Freezing ratio	0.7623	0.2378	0.0356
		Interest rate	0.754	0.2462	0.0371
Human capital	Staff	Employee salary growth rate	0.8152	0.1849	0.0259
		Employee welfare rate	0.6191	0.381	0.0615
		Safety rate	0.5866	0.4135	0.0675
		Executive salary growth rate	0.0608	0.9373	0.1381
Market capital	Suppliers	Payable turnover rate	0.1935	0.8046	0.1390
		Input ratio	0.8753	0.1228	0.0146
	Consumer	Sales growth rate	0.0163	0.9818	0.1710
Social capital	Government	Tax growth	0.768	0.23	0.0342
		Growth rate	0.8104	0.1877	0.0264
Ecological capital	Society	Donation ratio	0.8641	0.134	0.0166
	Environment	Reduced consumption of raw materials	0.7002	0.2979	0.0466

4. Analysis of the results of the comprehensive corporate financial evaluation

4.1. Analysis of the overall comprehensive evaluation of the enterprise's finances

In this paper, the data of Company M from 2017 to 2022 were selected as samples for analysis, and at the same time, entropy weighting method and gray correlation analysis were applied to sub-comprehensive assessment of its financial information over the past six years. The results of weighted correlation coefficients of the evaluation indexes and the correlation degree for the years of 2017-2022 are shown in Fig. 3.The results of the correlation degree (M) for the years of 2017-2022 are 0.722, 0.473, 0.398, 0.389, 0.426, and 0.496. the correlation of data indicators are ranked from largest to smallest in 2017, 2022, 2021, 2018, 2020, and 2019, respectively. That is, M Company has the best multidimensional financial comprehensive evaluation in 2017, the second best in 2022, and the worst comprehensive evaluation in 2020 during these six years.

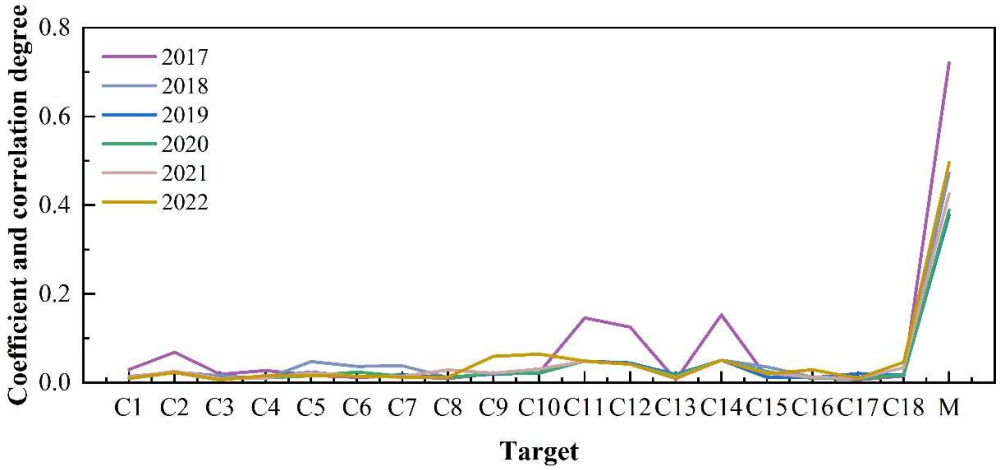

Fig. 3. The weighted correlation coefficient and the correlation result

4.2. Analysis of the dimensions of comprehensive corporate financial evaluation

4.2.1. Financial capital analysis. The indicator layer of the financial capital dimension is divided into seven indicators (C1~C7), including total net asset margin, total asset turnover, sales margin, dividend payout ratio, gearing ratio, quick ratio, and interest coverage multiple, and the trend of financial capital indicators is shown in Figure 4. It can be seen that the total net asset margin from 2017 to 2022 is in a continuous downward trend from 0.185 to 0.024, while the total asset turnover ratio is in a fluctuating downward trend. The sales margin is in a continuous downward trend, the dividend payout ratio is in a fluctuating trend, and overall there is an upward trend. Gearing ratio fluctuates little and shows an overall upward trend, quick ratio shows an upward trend followed by a downward and then back upward trend, and the interest coverage multiple rises substantially again from 2017 to 2018 and then declines substantially and continuously to 1.22 by 2022. And M's gearing ratio has been larger, meaning that M is less able to repay the loan. Meanwhile, M's interest coverage multiple surged to 4,283 in 2018, a dynamic that was likely influenced by the company's IPO, and has continued to decline since 2018, suggesting that the company's ability to raise debt to pay for its debts is gradually declining. On the whole, the overall performance of the state of the company's financial capital over the six-year period from 2017 to 2022 is gradually deteriorating.

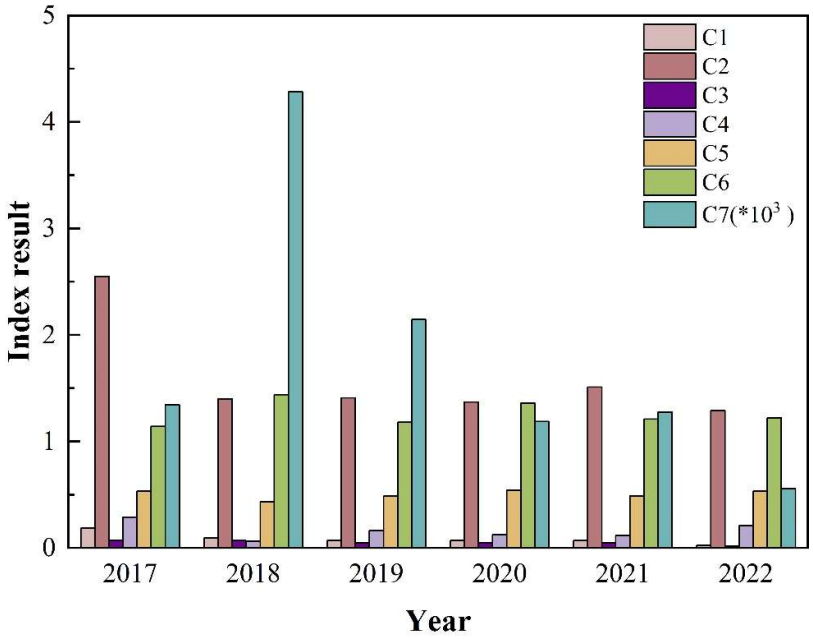

Fig. 4. Financial capital index trends

4.2.2. Human capital analysis. The indicator layer of human capital contains, i.e., employee salary growth rate, employee benefit rate, safe productivity expense rate, and executive salary growth rate (C8 to C11), and the trend of human capital indicators is shown in Fig. 5, from which it can be seen that employee salary growth rate of Company M shows a fluctuating growth and then decreasing trend from 2017 to 2022, the employee benefit rate shows a fluctuating growth trend, and the safe productivity rate shows a fluctuating growth trend from 2017 to 2020 was nearly unchanged and has been trending upward since 2020. The executive salary growth rate had an unusually high growth rate in 2017 (0.884), and the executive salary trend did not change very much from 2018, but showed an overall downward trend. Among them, the employee salary growth rate can reflect the trend of the enterprise on the change of employee salary, M company's employee salary growth rate from 2017 is an upward trend, to 2020 there is a relatively large decline and negative value, indicating that the

enterprise in this year may not have a certain increase in the employee salary. However, in 2021 the company's employee salary growth rate had a significant increase and more than doubled year-on-year, suggesting that the company had a significant increase in employee salaries in that year. Employee welfare rate can reflect to some extent the extent of the enterprise to the employee benefits, employee welfare rate in 2022 there is a substantial increase in the year-on-year growth of three times, indicating that the enterprise on the fulfillment of employee benefits more and more attention. The rate of production safety expenses can reflect the degree of importance the enterprise attaches to the employees in terms of production safety, and the rate of production safety expenses of Company M has a substantial increase in 2021-2022, indicating that the enterprise is investing more and more in production safety.

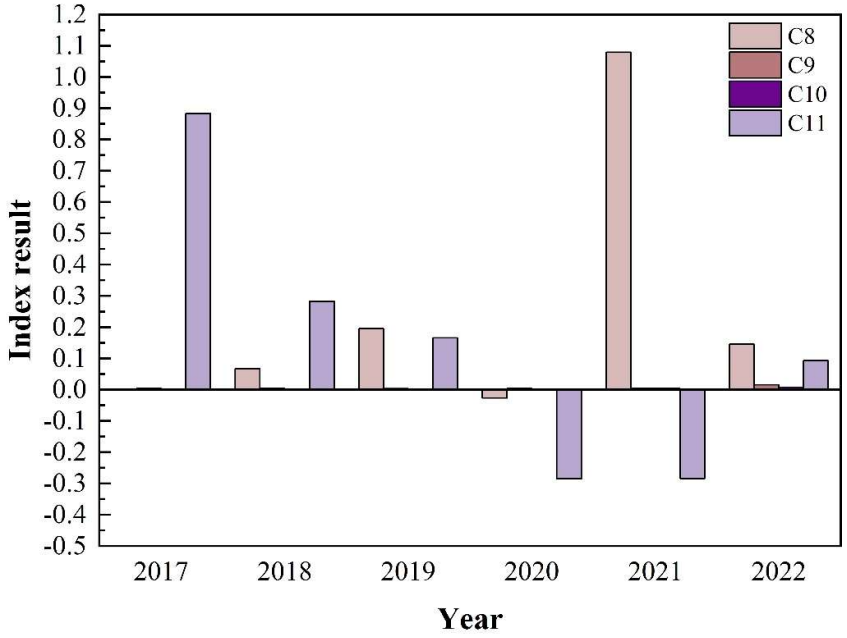

Fig. 5. Human capital index trend

4.2.3. Market, social and ecological capital analysis. The indicator layer of market, social and eco-capital includes accounts payable turnover, R&D investment ratio, sales growth rate, tax growth rate, employment growth rate, donation ratio and reduction in consumption of packaging raw materials, which are recorded as C12~C18, respectively, and the trends of market, social and eco-capital indicators are shown in Figure 6.The R&D investment ratio of Company M from 2017 to 2022 shows an increasing and then gradually decreasing trend, and the sales growth rate shows a significant decrease and then a slow recovery trend. The trend of sales growth rate in showing a substantial decline and then slowly rebound trend. The sales growth rate was at a high level in 2017, mainly due to the fact that the enterprise is in the stage of preparation for listing, and needs to store a large amount of capital to ensure that it can be listed successfully. In 2018, the sales growth rate had a substantial decline, and then slowly rose, indicating that the main business development of the enterprise is still gradually improving. Overall, the company's performance on consumer responsibility is better during the six years from 2017 to 2022.The accounts payable turnover index from 2017 to 2022 shows a gradual downward trend, and M should focus on the construction of supply chain integration and insist on promoting win-win cooperation with suppliers.

From the data of these six years, M Company's contribution to tax revenue is less stable, but from M Company's annual report as well as the sustainability report, the company actively implements relevant government requirements, pays taxes on time and contributes to the country's economic

development. Overall, M Company's performance on government responsibilities from 2017 to 2022 is better.

In terms of eco-capital, M Company's performance on social responsibility is at a medium level and there is still some room for development. In terms of the trend of the reduction in the consumption of packaging raw materials, the company's performance on environmental responsibility is better and should be maintained or continuously strengthened.

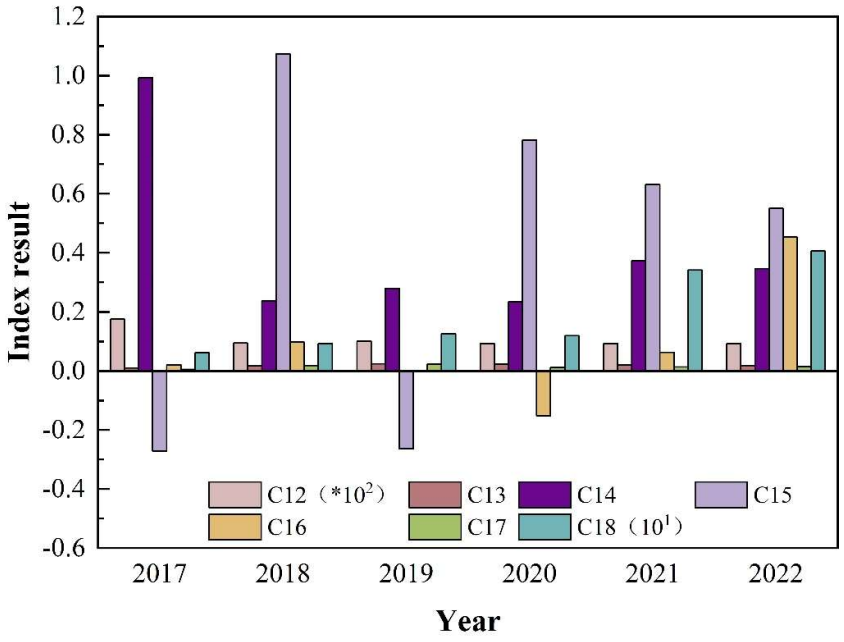

Fig. 6. Market, society and ecological capital index trends

5. Conclusion

This study combines the entropy weight method with gray correlation analysis to construct a comprehensive evaluation system of enterprise financial indicators under a multidimensional perspective, and conducts a comprehensive evaluation and analysis of M Company's financial performance.

The multidimensional financial comprehensive evaluation index system constructed in this paper consists of four target layers, including financial capital, human capital, market social capital, social capital, and ecological capital. Under it, 8 indicators including shareholders, creditors, employees, suppliers, consumers, government, society and environment constitute the criterion layer and 18 indicator layers. Sales growth rate, accounts payable turnover rate and executive salary growth rate are the three indicators with the highest weights of 0.1710, 0.1390 and 0.1381 respectively, indicating that these three indicators are important factors affecting the evaluation results of enterprises.

In this paper, combined with practice, the comprehensive evaluation of M company is analyzed, and the correlation of financial data indicators from 2017 to 2022 are arranged in ascending order as 2017 (0.722) > 2022 (0.496) > 2021 (0.473) > 2018 (0.426) > 2020 (0.398) > 2019 (0.389). This indicates that Company M has the best overall evaluation result in 2017 and the worst overall evaluation in 2020.

In terms of the dimensions, the overall performance of the state of the company's financial capital has been getting progressively worse over the six-year period from 2017 to 2022, but the growth rate of the company's employee payroll has increased significantly in 2021, more than doubling year-on-year, and the performance of its responsibility to employees has been progressively moving in a good direction. Secondly, Company M's performance on responsibility to consumers and government has

been at a good level, while ecological responsibility is at a medium level. Taken together, Company M still has some room for improvement in the results of each indicator of the comprehensive evaluation.

References

[1] Guo, Z. (2020). Evaluation of financial ability of port listed companies based on entropy weight TOPSIS model. Journal of Coastal Research, 103(SI), 182-185.

[2] Islamoglu, M., Apan, M., & Oztel, A. (2015). An evaluation of the financial performance of REITs in Borsa Istanbul: A case study using the entropy-based TOPSIS method. International Journal of Financial Research, 6(2), 124-138.

[3] Fan, R., & Cao, W. (2022). An empirical analysis of financial ecological environment evaluation of Guangzhou and Shenzhen—Based on entropy weight method and K-means clustering method. Acad. J. Bus. Manag, 5, 99-104.

[4] Wang, Q., Yuan, X., Zhang, J., Gao, Y., Hong, J., Zuo, J., & Liu, W. (2015). Assessment of the sustainable development capacity with the entropy weight coefficient method. Sustainability, 7(10), 13542-13563.

[5] Benedetto, F., Mastroeni, L., & Vellucci, P. (2021). Modeling the flow of information between financial time-series by an entropy-based approach. Annals of Operations Research, 299(1), 1235-1252.

[6] Zhang, Y., & Shang, P. (2018). Refined composite multiscale weighted-permutation entropy of financial time series. Physica A: Statistical Mechanics and its Applications, 496, 189-199.

[7] Ünvan, Y. A., & Ergenç, C. (2022). Financial performance analysis with the fuzzy COPRAS and entropy-COPRAS approaches. Computational Economics, 59(4), 1577-1605.

[8] Li, L. (2023, February). Research on Financial Performance Evaluation of Chinese Listed Logistics Enterprises Based on Entropy Weight Method. In Proceedings of the 4th International Conference on Economic Management and Model Engineering, ICEMME 2022, November 18-20, 2022, Nanjing, China.

[9] Lee, P. T. W., Lin, C. W., & Shin, S. H. (2018). Financial performance evaluation of shipping companies using entropy and grey relation analysis. Multi-Criteria Decision Making in Maritime Studies and Logistics: Applications and Cases, 219-247.

[10] Yinping, Z. (2015, December). The research of the enterprise financial model based on information entropy and correlation model reorganization theory. In 2015 International Conference on Intelligent Transportation, Big Data and Smart City (pp. 910-913). IEEE.

[11] Xu, H. (2023). Financial performance evaluation of listed companies in a-share pharmaceutical industry—A model based on entropy method-coefficient of variation method. Accounting, Auditing and Finance, 4(3), 18-26.

[12] Wang, T., & Deng, X. (2021, December). Study on Establishment of Enterprise Financial Risk Assessment Model Based on Entropy Weight TOPSIS. In 2021 3rd International Conference on Economic Management and Cultural Industry (ICEMCI 2021) (pp. 3380-3385). Atlantis Press.

[13] Daier, J. D., Zayer, A. K. Y., & Rodin, W. M. (2022). Assessing The Financial Performance Of Construction Companies Using The Entropy Method. Journal of Positive School Psychology, 6(7), 2200-2223.

[14] Liu, Y., Qin, P., & Fu, L. (2024). Research on the Application of Entropy Method and Efficiency Coefficient Method in Financial Risk Early Warning of Enterprises: Taking Shandong Longda Meishi Co., Ltd. as an Example. Frontiers in Business, Economics and Management, 14(1), 254-259.

[15] Erdogan, H. H. (2023). Entropy-based Waspas approach for financial performance in the Covid-19 era: Evidence from Islamic countries. Financial Internet Quarterly, 19(3), 48-61.

[16] Günay, F., & Ecer, F. (2020). Cash flow based financial performance of Borsa İstanbul tourism companies

by Entropy-MAIRCA integrated model. Journal of multidisciplinary academic tourism, 5(1), 29-37.

[17] Jin, H., & Wang, Z. (2024, April). Research on Financial Risk Evaluation of Internet Technology Industry Based on Entropy Weight Method—Taking Xiaomi Group as an Example. In International Conference on Computational Finance and Business Analytics (pp. 420-436). Cham: Springer Nature Switzerland.

[18] Chen, W. (2023). An enterprise financial data risk prediction model based on entropy weight method. International Journal of Industrial and Systems Engineering, 45(1), 89-100.

[19] Liew, K. F., Lam, W. S., & Lam, W. H. (2022). Financial network analysis on the performance of companies using integrated entropy–DEMATEL–TOPSIS model. Entropy, 24(8), 1056.

[20] Lam, W. H., Lam, W. S., Liew, K. F., & Lee, P. F. (2023). Decision analysis on the financial performance of companies using integrated entropy-fuzzy topsis model. Mathematics, 11(2), 397.

[21] Wang, L., & Mao, G. (2023). Application of Entropy Weight TOPSIS Method in Financial Risk Assessment of Liquor Listed Companies: Take Shanxi Fenjiu As an Example. Frontiers in Business, Economics and Management, 9(2), 168-173.

[22] Lam, W. S., Lam, W. H., Jaaman, S. H., & Liew, K. F. (2021). Performance evaluation of construction companies using integrated entropy–fuzzy VIKOR model. Entropy, 23(3), 320.

[23] Gartner, I. R. (2015). Multi-attribute utility model based on the maximum entropy principle applied in the evaluation of the financial performance of Brazilian banks. Decision models in engineering and management, 29-55.