

Application of Improved Entropy TOPSIS to Competitive Performance Evaluation of Power Companies

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Abstract. The improved entropy TOPSIS method is applied in evaluating the competitive performance of power listed companies. The proposed method can fully consider the amount and quality of information, which also can overcome the influence of subjective factors in determining the evaluation index weight of the traditional TOPSIS. Through a specific example, we can conclude that the improved entropy TOPSIS method is useful and credible.

Introduction

According to the source of corporate competitiveness, the competitiveness of the listed power company can be divided into potentially competitiveness, realistic competitiveness and performance competitiveness. Evaluating the performance competitiveness of the power listed companies can understand the relative status between power producers and competitors, find their own strengths and weaknesses, so as to provide reference and basis for enterprises to enhance their competitiveness [1,2].

Throughout the world, we will enter the era of innovation-intensive, when the new industries led by technology and economy would be the dominate force to promote the development of the world economy in the future. Innovative enterprises are the fundamental forces in the innovation-oriented country. Building innovative enterprise is an irresistible trend of economic development all over the world and enhancing the overall national strength, which is also the basic power to realize building an innovation-oriented country. Enhancing the competitiveness of innovative enterprises, which can convert the economic development from resource-dependent to technology-driven type, must be addressed to improve our capacity for independent innovation and achieve sustainable development of the productive forces of science and building an innovative country. Seventeenth party congress made it clear that accelerating the establishment of technological innovation system, which the mainstay of is enterprises, market-oriented and combined by manufacture, studying and researching; guiding and supporting innovative elements into enterprises; accelerating the formation of a number of competitive and innovative enterprises promoting scientific and technological achievements into practical productive forces[3,4].

At present, the study of the innovative enterprises is still in the primary stage at home and abroad. There are two reasons. The first reason is that ,as a new thing, the innovative business models is not long, whose nature is not yet stable, so that the theoretical study of innovative enterprises is also relatively new research field theory. The second reason is that, theorists have not formed an accepted fixed definition of innovative business models and lacking of a systematic study of this issue. At the moment, scholars research about innovative companies focus on the concept of thematic research, dynamic mechanism, influencing factors, property rights, innovation, incentives, etc. The above findings have an important implications for inspiration and reference to this paper, laid the framework and foundation for further research in this paper. But according to the existing literature on the screen and analyzing, the research of innovation-oriented enterprises in the following areas is still insufficient, needing improvement[5,6].

Establishment of competitive performance evaluation index system

According to the financial indicators measuring, the power listed companies' competitive performance is mainly composed of four parts, namely, the ability to benefit, operations, solvency and development capacity. Combined with the reality of statistical indicators of accessibility, this paper constructs a four-level index system containing seven indicators, which is shown in Table 1 [7].

Table 1: Evaluation index system

Evaluation index system of competitive performance	Benefits capacity	Return on equity (C1)
		Net profit margin (C2)
	Operational capacity	Total asset turnover (C3)
	Solvency	Asset-liability ratio (C4)
		Main business revenue growth (C5)
	Development capacity	Growth rate of total assets (C6)
		Net profit growth rate (C7)

Improved entropy weight and TOPSIS

Entropy is a stem from thermodynamics, then it was introduced in information theory by Shannon. According to the definition and principle of entropy, when the system might be in several different states, the probability of each state appears to p_i , the entropy of the system is defined as follows [8]:

$$h = -\sum_{i=1}^m p_i \ln p_i \quad (1)$$

Where p_i satisfies $0 \leq p_i \leq 1$ and $\sum_{i=1}^m p_i = 1$.

Obviously, when the probability of each state appears equal, namely, $p_i = \frac{1}{m}$, the entropy obtains the largest value $H_{\max} = \ln m$.

For the evaluation problem, supposing there are n evaluation objects and m evaluation indicators. The original data matrix is constructed as $X = (x_{ij})_{m \times n}$, where x_{ij} represents the j -th indicator value of the i -th object. The information entropy of indicator x_{ij} is defined as follows:

$$h_j = -\frac{1}{\ln m} \sum_{i=1}^m p_{ij} \ln p_{ij} \quad (2)$$

Where $p_{ij} = x_{ij} / \sum_{i=1}^m x_{ij}$. As can be seen, when the entropy index value is higher, the indicator provides less useful information, which has a smaller weight. On the contrary, when the entropy index value is lowers, the indicator provides more useful information, which has a larger weight. Therefore, in the specific analysis process, the entropy method can be used to determine the weight of indicators.

TOPSIS method is used in the evaluation of the competitive performance, which is to find a comparison reference value, the ideal solution and negative ideal solution. The ideal solution means

the best and worst index value of the same indicators in a company over years. The negative ideal solution means the best and worst index value of the company in the same industry. Considering the index value for each program with the ideal solution and the negative ideal solution, the closer with the ideal solution, the better illustrate the competitive performance.

Evaluation of competitive performance based on improved entropy TOPSIS

The evaluation process of improved entropy TOPSIS is shown as follows:

Set m companies need to be evaluated and n evaluation indicators. The original data matrix is $X = (x_{ij})_{m \times n}$.

Step1: Take the positive treatment and non-dimensional treatment to matrix X , the matrix after processing is defined as Y .

If the j -th indicator x_j is a positive indicator, it is converted as Eq.(3):

$$y_{ij} = \frac{x_{ij} - \min_i(x_{ij})}{\max_i(x_{ij}) - \min_i(x_{ij})}, \quad i = 1, 2, \dots, m, \quad j = 1, 2, \dots, n. \quad (3)$$

If the j -th indicator x_j is a negative indicator, it is converted as Eq.(4):

$$y_{ij} = \frac{\max_i(x_{ij}) - x_{ij}}{\max_i(x_{ij}) - \min_i(x_{ij})}, \quad i = 1, 2, \dots, m, \quad j = 1, 2, \dots, n. \quad (4)$$

If the j -th indicator x_j is an interval indicator, which means that the x_j is the best in $[m_1, m_2]$, it is converted as Eq.(5):

$$y_{ij} = \begin{cases} \frac{x_{ij} - \min_i(x_{ij})}{m_1 - \min_i(x_{ij})} & \min_i(x_{ij}) \leq x_{ij} \leq m_1 \\ 1 & m_1 \leq x_{ij} \leq m_2 \\ \frac{\max_i(x_{ij}) - x_{ij}}{\max_i(x_{ij}) - m_2} & m_2 \leq x_{ij} \leq \max_i(x_{ij}) \end{cases} \quad (5)$$

Step2: Calculate the value of p_{ij} , which represents the j -th indicator proportion of the i -th company.

$$p_{ij} = \frac{y_{ij}}{\sum_{i=1}^m y_{ij}} \quad (6)$$

Step3: Calculate the entropy value h_j of the j -th indicator.

$$h_j = -\frac{1}{\ln m} \sum_{i=1}^m p_{ij} \ln p_{ij}, \quad j = 1, 2, \dots, n. \quad (7)$$

Step4: Calculate the difference coefficient g_j of the j -th indicator. For the j -th indicator, if the value of h_j is smaller, the difference degree of the indicator value is larger, and its difference coefficient is smaller. The difference coefficient is defined as follows:

$$g_j = 1 - h_j. \quad (8)$$

Step5: Calculate the weight w_j of the j -th indicator.

$$w_j = \frac{g_j}{\sum_{j=1}^n g_j}, \quad 0 \leq w_j \leq 1, \quad \sum_{j=1}^n w_j = 1. \quad (9)$$

Step6: Construct the weighted data matrix Z , which its element z_{ij} is defined as follows:

$$z_{ij} = w_j \cdot y_{ij}, i = 1, 2, \dots, m, j = 1, 2, \dots, n. \quad (10)$$

Step7: Determine the ideal value and the negative ideal value, respectively form ideal value vector Z^+ and the negative ideal value vector Z^- .

$$Z^+ = (z_1^+, z_2^+, \dots, z_m^+). \quad (11)$$

$$Z^- = (z_1^-, z_2^-, \dots, z_m^-). \quad (12)$$

Where $z_j^+ = \max(z_{1j}, z_{2j}, \dots, z_{mj})$ and $z_j^- = \min(z_{1j}, z_{2j}, \dots, z_{mj})$.

Step8: Calculate the evaluation index vector objects and the distance between the ideal value vector. Distance formula using Euclidean distance formula, namely:

$$D_i^+ = \sqrt{\sum_{j=1}^m (z_{ij} - z_i^+)^2}, \quad i = 1, 2, \dots, m. \quad (13)$$

$$D_i^- = \sqrt{\sum_{j=1}^m (z_{ij} - z_i^-)^2}, \quad i = 1, 2, \dots, m. \quad (14)$$

Step9: Calculate relative proximity between the evaluation objects index vector with the ideal value vector according to Eq.(15).

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-}. \quad (15)$$

Step10: Sort the evaluation object according to the close degree. For C_i ranging from 0 to 1, when the evaluation object index vector equals the ideal value vector, C_i equals 1. On the contrary, when the evaluation object index vector equals the negative ideal value vector, C_i equals 0. When C_i is more close to 1, the corresponding evaluation objects should be at the top.

Specific example and results analysis

Fourteen power companies listed in Shanghai Stock Exchange applied the proposed method to evaluate their competitive performance. The specific data are shown in Table 2.

Table 2: The original data

Company label	C1 [%]	C2[%]	C3 [%]	C4 [%]	C5 [%]	C6 [%]	C7[%]
1	8.41	11.44	0.32	32.13	15.63	0.87	29.09
2	4.77	8.48	0.23	48.43	22.22	21.05	14.65
3	3.85	8.78	0.21	39.03	6.86	20.16	750.31
4	0.81	3.41	0.16	29.56	8.72	17.99	-58.18
5	3.38	1.12	0.21	81.86	51.45	36.65	162.51
6	-4.53	-15.34	0.12	48.93	-9.23	18.92	-10.58
7	6.93	12.66	0.22	56.47	16.81	6.02	47.85
8	3.31	5.36	0.19	53.09	-4.84	9.38	10.16
9	3.23	6.54	0.18	64.31	15.42	31.85	330.24
10	0.93	1.95	0.17	62.85	0.96	-1.56	-45.01
11	-3.16	-5.17	0.16	73.28	42.72	3.91	43.95
12	11.24	16.08	0.31	54.39	4.98	-7.78	137.88
13	6.32	7.61	0.16	72.52	41.96	34.09	49.65
14	3.82	8.44	0.23	46.55	0.36	13.84	-24.42

The data after the synthetic and dimensionless processing are shown in Table 3

Table 3: The data after processing

Company label	C1 [%]	C2 [%]	C3 [%]	C4 [%]	C5 [%]	C6 [%]	C7 [%]
1	0.821	0.852	1.000	0.951	0.409	0.195	0.108
2	0.589	0.758	0.550	0.639	0.518	0.649	0.091
3	0.531	0.768	0.450	0.819	0.265	0.629	1.000
4	0.338	0.596	0.200	1.000	0.296	0.581	0.000
5	0.502	0.524	0.450	0.000	1.000	1.000	0.273
6	0.000	0.000	0.000	0.629	0.000	0.601	0.059
7	0.727	0.891	0.500	0.486	0.429	0.311	0.131
8	0.497	0.659	0.350	0.551	0.072	0.386	0.085
9	0.492	0.696	0.300	0.336	0.406	0.892	0.481
10	0.346	0.551	0.250	0.364	0.168	0.141	0.016
11	0.087	0.324	0.200	0.164	0.856	0.263	0.126
12	1.000	1.000	0.900	0.525	0.234	0.000	0.243
13	0.688	0.731	0.200	0.179	0.844	0.942	0.133
14	0.529	0.757	0.550	0.675	0.158	0.487	0.042

The entropy value, difference coefficient and the weight are calculated. Their results are shown in Table 4.

Table 4: The results of entropy, difference coefficient and weight

Indicator	C1	C2	C3	C4	C5	C6	C7
Entropy value	0.946	0.966	0.913	0.935	0.912	0.902	0.813
Difference coefficient	0.107	0.086	0.124	0.114	0.149	0.122	0.257
Weight	0.112	0.099	0.129	0.119	0.155	0.127	0.268

After calculation, C_i and sort results are required, which are shown in Table 5.

Table 5: The rankings results

Company label	C_i	Rankings	Company label	C_i	Rankings
1	4.336	2	8	2.598	11
2	3.794	4	9	3.603	7
3	4.462	1	10	1.834	13
4	3.010	10	11	2.020	12
5	3.749	5	12	3.902	3
6	1.289	14	13	3.716	6
7	3.474	8	14	3.198	9

As we can see from Table 4, the results of improved entropy TOPSIS method to evaluate the power company competitive are basically consistent with the actual situation, indicating that the proposed method is feasible. Therefore the proposed model applying in evaluating the competitive performance of the power companies is feasible.

Conclusions

Improved entropy TOPSIS evaluation method can fully consider the amount and quality of information, while overcoming the impact of the traditional TOPSIS method in determining the evaluation index weight factor of subjective factors. It is used to evaluate the competitive performance of the power companies. The results are fair and objective, which can also provide the data support timely for companies to adjust internal deficiencies reasonably.

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