Financial Performance Evaluation of Listed Companies Based on Improved Catastrophe Progression Method——Take the express industry as an example

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Abstract. As China’s express delivery industry plays an increasingly important role in the national economy, evaluating its financial performance has become an unavoidable issue for operators and investors. This paper constructs a financial performance evaluation index system for listed companies, and uses the entropy weight-Catastrophe progression method to evaluate the financial performance of listed companies in China’s express delivery industry from 2017 to 2020, and makes a brief analysis of the evaluation results. Studies have shown that it is feasible to evaluate the financial performance of listed companies through the improved catastrophe progression method. The evaluation results can reflect the weakness in the development of companies and provide references for operation and investment decisions.

1. Introduction
In recent years, with the development of the e-commerce industry, China’s express delivery industry has also ushered in a golden period of development. According to the data disclosed by the State Post Bureau, my country’s express delivery business volume and business income are growing year by year from 2015 to 2020, and the express delivery industry is playing an increasingly important role in the national economy. In this context, the evaluation of the financial performance of listed companies in the express delivery industry can provide important reference information for operators to analyze the weaknesses of the company’s development and find out the gap with competitors; it is helpful for investors to distinguish the quality of the company’s development and reasonable investment decisions. Based on the existing research results, this paper constructs a financial performance evaluation index system for listed companies, and evaluates the financial performance of listed companies in China’s express delivery industry through an Improved catastrophe progression method.

2. Theoretical basis
2.1. Entropy method
Entropy was first introduced by Shannon to information theory. The basic idea of the entropy method is to determine the objective weight according to the variability of the index. The specific calculation steps of the entropy method are as follows[1]:

(a) If it is a positive indicator, the larger the value, the better, then there is

\[ X'_i = \frac{X_i - X_{min}}{X_{max} - X_{min}} \]  

On the contrary, there is

\[ X'_i = 1 - \frac{X_i - X_{min}}{X_{max} - X_{min}} \]  

In the above formula, $X'_i$ is the dimensionless index value, $X'_i$ is the original data of the index, and $X_{\text{max}}$ and $X_{\text{min}}$ are the maximum and minimum values obtained by the index, respectively. The processed matrix is denoted as

$$H' = (h'_{ij})_{n \times m}$$

(b) Calculate the proportion of the i-th evaluation object in the index under the j-th index

$$p_{ij} = \frac{h'_{ij}}{\sum_{i=1}^{m} h'_{ij}} \quad i = 1, 2, \ldots, n, j = 1, 2, \ldots, m$$

Obviously,

$$\sum_{i=1}^{m} p_{ij} = 1$$

(c) Calculate the information entropy value of the j-th indicator

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij}, \quad j = 1, 2, \ldots, m$$

Among them,

$$k = \frac{1}{ln (n)}$$

(d) Calculate the weight of each indicator

$$q_j = \frac{1 - e_j}{m - \sum e_j}$$

2.2. Catastrophe progression method

Catastrophe progression method is a comprehensive evaluation method based on catastrophe theory. When using this method, it is necessary to decompose the evaluation target layer by layer to build an evaluation index system, and then start from the bottom index, calculate the membership function value of each index according to the normalization formula, and then recursively calculate the control variables of the upper index layer by layer[2]. The value of, finally obtains the total catastrophe membership function value of the system, so as to sort and select the scheme.

According to the classification theorem proposed by Thom, the founder of catastrophe theory, catastrophe models can be divided into two categories: cusp-like catastrophe and umbilical catastrophe. Among them, the type of catastrophe model whose state variables are one-dimensional is called cusp-like mutation[3]. This article only discusses cusp-like mutations. There are four common types, and their potential functions and normalized formulas are as follows[Table 1].

| Catastrophe Models | Potential Function | Normalized Formulas |
|--------------------|--------------------|---------------------|
| Fold model         | $f(x) = x^3 + ax$  | $x_a = \frac{1}{|a|^2}$ |
| Cusp model         | $f(x) = x^4 + ax^2 + bx$ | $x_a = \frac{1}{|a|^2}, x_b = |b|^3$ |
| Swallowtail model  | $f(x) = x^5 + ax^3 + bx^2 + cx$ | $x_a = \frac{1}{|a|^2}, x_b = |b|^3, x_c = |c|^4$ |
| Butterfly model    | $f(x) = x^6 + ax^4 + bx^3 + cx^2 + dx$ | $x_a = \frac{1}{|a|^2}, x_b = |b|^3, x_c = |c|^4, x_d = |d|^5$ |

In table 1, $x$ is the state variable in the catastrophe system, $f(x)$ is the potential function of the state variable, and $a, b, c, d$ are the control variables of the state variable.
3. Financial performance evaluation of listed companies in the express delivery industry

3.1. Index system construction
According to the "Four Ability Theory" widely used in the industry, this article divides the evaluation indicators into four aspects: operating ability, development ability, profitability, and solvency to comprehensively reflect the company's financial performance, and build financial performance evaluation indicators for listed companies in the express delivery industry system[4]-[5]. (Table 2)

Table 2. Index system of listed company's financial performance evaluation

| First-level index | Second-level index          | Third-level index                        |
|-------------------|-----------------------------|------------------------------------------|
| Operating ability | Accounts receivable turnover rate C₁ | Total asset turnover rate C₂            |
|                   |                             | Liquid assets turnover rate C₃           |
| Development ability | Total assets growth rate C₄ | Owner's equity growth rate C₅           |
|                   |                             | Net profit growth rate C₆               |
| Profitability     | Cost and expense profit margin C₇ | Operational profit margin C₈            |
|                   |                             | Net profit margin of total assets C₉    |
| Profitability     | Return on net assets C₁₀    |                                         |
| Solvency          | Current ratio C₁₁           |                                         |
|                   | Net cash flow from operational activities/total liabilities C₁₂ | |
|                   | Asset-liability ratio C₁₃  | Net cash flow from operational activities/current liabilities C₁₄ |

3.2. Data processing

3.2.1. Data source and dimensionless processing
This article uses the CSMAR database to obtain the financial indicator data of the 2017-2020 annual report consolidated financial statements of five listed companies in the express delivery industry, Shentong, Yunda, SF, YTO, and Debon. Before calculating the index entropy value, the data need to be dimensionlessly processed by formula (1) and formula (2). (Table 3)

Table 3. Standardized results of three-level indicators

| Company Name | Fiscal Year | C₁   | C₂   | C₃   | C₄   | C₅   | C₆   | C₇   |
|--------------|-------------|------|------|------|------|------|------|------|
| Yunda        | 2017        | 0.524| 0.126| 0.192| 0.366| 0.355| 0.765| 0.838|
|              | 2018        | 0.405| 0.000| 0.000| 1.000| 1.000| 0.937| 1.000|
|              | 2019        | 1.000| 0.324| 0.463| 0.176| 0.172| 0.569| 0.334|
|              | 2020        | 0.988| 0.157| 0.288| 0.257| 0.087| 0.297| 0.156|
| SF           | 2017        | 0.076| 0.198| 0.236| 0.251| 0.511| 0.647| 0.294|
|              | 2018        | 0.062| 0.214| 0.390| 0.085| 0.130| 0.528| 0.200|
|              | 2019        | 0.004| 0.189| 0.328| 0.230| 0.150| 0.716| 0.206|
|              | 2020        | 0.000| 0.263| 0.423| 0.124| 0.304| 0.700| 0.203|
| Shentong     | 2017        | 0.213| 0.285| 0.209| 0.008| 0.230| 0.668| 0.569|
|              | 2018        | 0.180| 0.284| 0.365| 0.301| 0.246| 0.786| 0.572|
|              | 2019        | 0.432| 0.382| 0.581| 0.084| 0.093| 0.384| 0.253|
|              | 2020        | 0.328| 0.249| 0.472| 0.063| 0.000| 0.000| 0.000|
3.2.2. Data entropy weight processing

The index weight calculated by the entropy method ranks the relative importance of each index, which can reduce the subjectivity of artificial ranking. According to the operation process of the entropy method, MATLAB is used to calculate the weights of the three-level indicators, and to determine the mutation types of the indicators at all levels. (Table 4)

| Company Name | Fiscal Year | C8  | C9  | C10 | C11 | C12 | C13 | C14 |
|--------------|-------------|-----|-----|-----|-----|-----|-----|-----|
| Yunda        | 2017        | 0.832 | 0.976 | 1.000 | 0.083 | 0.832 | 0.348 | 0.645 |
|              | 2018        | 1.000 | 0.829 | 0.740 | 0.296 | 0.663 | 0.593 | 0.478 |
|              | 2019        | 0.391 | 0.671 | 0.635 | 0.126 | 0.609 | 0.481 | 0.476 |
|              | 2020        | 0.188 | 0.265 | 0.314 | 0.228 | 0.047 | 0.134 | 0.100 |
| SF           | 2017        | 0.336 | 0.465 | 0.470 | 0.237 | 0.131 | 0.376 | 0.158 |
|              | 2018        | 0.230 | 0.347 | 0.389 | 0.107 | 0.047 | 0.211 | 0.072 |
|              | 2019        | 0.238 | 0.341 | 0.426 | 0.198 | 0.086 | 0.037 | 0.169 |
|              | 2020        | 0.238 | 0.347 | 0.392 | 0.121 | 0.089 | 0.199 | 0.144 |
| Shentong     | 2017        | 0.566 | 0.976 | 0.723 | 1.000 | 0.934 | 1.000 | 1.000 |
|              | 2018        | 0.605 | 1.000 | 0.791 | 0.463 | 1.000 | 0.854 | 0.727 |
|              | 2019        | 0.293 | 0.582 | 0.500 | 0.207 | 0.425 | 0.677 | 0.319 |
|              | 2020        | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.332 | 0.001 |
| YTO          | 2017        | 0.340 | 0.582 | 0.503 | 0.285 | 0.311 | 0.668 | 0.230 |
|              | 2018        | 0.340 | 0.553 | 0.534 | 0.431 | 0.262 | 0.447 | 0.381 |
|              | 2019        | 0.266 | 0.429 | 0.409 | 0.275 | 0.361 | 0.466 | 0.588 |
|              | 2020        | 0.230 | 0.394 | 0.334 | 0.000 | 0.298 | 0.671 | 0.292 |
| Debon        | 2017        | 0.117 | 0.476 | 0.581 | 0.094 | 0.525 | 0.075 | 0.504 |
|              | 2018        | 0.133 | 0.482 | 0.568 | 0.167 | 0.328 | 0.134 | 0.283 |
|              | 2019        | 0.043 | 0.194 | 0.250 | 0.043 | 0.000 | 0.000 | 0.000 |
|              | 2020        | 0.082 | 0.306 | 0.392 | 0.016 | 0.230 | 0.022 | 0.227 |

3.2.2.1. Data entropy weight processing

The index weight calculated by the entropy method ranks the relative importance of each index, which can reduce the subjectivity of artificial ranking. According to the operation process of the entropy method, MATLAB is used to calculate the weights of the three-level indicators, and to determine the mutation types of the indicators at all levels. (Table 4)

| Second-level index | Third-level index                               | Weights | Ranking | Model type    |
|--------------------|-------------------------------------------------|---------|---------|---------------|
| Operating ability B1 | Accounts receivable turnover rate C1 | 0.462   | 1       | Swallowtail model |
|                     | Total asset turnover rate C2                   | 0.329   | 2       |               |
|                     | Liquid assets turnover rate C3                 | 0.209   | 3       |               |
| Development Ability B2 | Total assets growth rate C4              | 0.538   | 1       | Swallowtail model |
|                     | Owner's equity growth rate C5                | 0.350   | 2       |               |
|                     | Net profit growth rate C6                    | 0.112   | 3       |               |
3.2.3. Catastrophe progression method evaluation results

This article uses the catastrophe progression method to evaluate the financial performance of five listed companies in the express delivery industry from 2017 to 2020. Due to space limitations, this article takes the calculation of the financial performance evaluation value of Yunda in 2017 as an example, and the evaluation results of other companies and other years are analogized.

(a) Standardized processing of financial indicator data

Before using the catastrophe progression method to calculate the membership function value, it is also necessary to eliminate the influence of each index dimension, as shown in Table 3.

(b) Calculate the membership function value of the secondary index mutation

According to the dimensionless data, the evaluation value of the third-level indicators in 2017 is calculated by the normalization formula, and then the evaluation value of each second-level indicator is calculated according to the principle of "complementarity". Taking Yunda's profitability index as an example, the three-level indicators under profitability constitute a butterfly mutation, so the calculation method is as follows.

\[ X_{C_7} = \sqrt{C_7} = \sqrt{0.838} = 0.9154 \]
\[ X_{C_8} = \sqrt[4]{C_8} = \sqrt[4]{0.832} = 0.9405 \]
\[ X_{C_9} = \sqrt[6]{C_9} = \sqrt[6]{0.976} = 0.9939 \]
\[ X_{C_{10}} = \sqrt[10]{C_{10}} = \sqrt[10]{1} = 1 \]
\[ X_{B_3} = \frac{X_{C_7} + X_{C_8} + X_{C_9} + X_{C_{10}}}{4} = 0.9625 \]

Using the same calculation method, the catastrophe membership function values of the secondary indicators of each company in 2017 can be obtained. (Table 5)

|   | B1  | B2  | B3  | B4  |
|---|-----|-----|-----|-----|
| Yunda | 0.6291 | 0.7494 | 0.9625 | 0.7282 |
| SF | 0.5185 | 0.7324 | 0.7308 | 0.6173 |
| Shentong | 0.5986 | 0.5354 | 0.8782 | 0.9944 |
| YTO | 0.6370 | 0.6182 | 0.7497 | 0.7152 |
| Debon | 0.8246 | 0.5898 | 0.6308 | 0.6271 |

(c) Calculate first-level indicators

After calculating the evaluation value of the secondary indicators, the secondary indicators need to be further integrated according to the normalization formula, and finally the financial performance evaluation value of Yunda in 2017

\[ X_{Yunda2017} = \frac{\sqrt{B_1} + \frac{3}{4}\sqrt{B_2} + \frac{4}{5}\sqrt{B_3} + \frac{5}{6}\sqrt{B_4}}{4} = 0.9076 \]

Repeat the above calculation steps to calculate the 2017-2020 financial performance evaluation values of the five express companies. The specific calculation results are shown in Table 6. It can be
seen from the table that the best comprehensive evaluation result is Yunda shares, followed by YTO Express, and Shentong Express’s sudden “fall behind” in 2020 should attract the attention of its operators and investors.

| Year | Yunda | SF    | Shentong | YTO    | Debon  |
|------|-------|-------|----------|--------|--------|
| 2017 | 0.9076| 0.8635| 0.8881   | 0.8789 | 0.8872 |
| 2018 | 0.8515| 0.8319| 0.9066   | 0.8947 | 0.8906 |
| 2019 | 0.9108| 0.8307| 0.8820   | 0.8723 | 0.7379 |
| 2020 | 0.8647| 0.8363| 0.5175   | 0.8773 | 0.8567 |

4. Summary and outlook
Taking the express delivery industry as an example, this article uses the catastrophe progression method to evaluate the financial performance of five listed companies in the industry from 2017 to 2020. By combining the entropy weight method with the catastrophe progression method, the scientific nature of the relative importance of indicators is improved. It provides a new reference for the evaluation of corporate financial performance. At the same time, this article also has certain limitations. For example, in the setting of indicators, only financial indicators are set, but non-financial indicators are not taken into account, and the set indicators do not take into account the particularity of the express industry; The use of "complementary" and "non-complementary" criteria mainly rely on expert experience, making the evaluation results inevitably subjective. In addition, the entropy method completely reflects the evaluation index weight based on the degree of variation of the original index data, so the determined index weight may be different from the true importance of the index due to the sudden change of the original data. In summary, this article proposes a new method of performance evaluation of listed companies, but the relevant details need to be continuously deepened in follow-up research.

References
[1] Wang Yongxiang, Wu Tao, Li Liang, Huang Ying, Geng Daxin. (2021) Safety risk assessment of subway shield construction based on catastrophe progression method. J. Safety and Environmental Engineering, 28(01): 95-102.
[2] Zhen Junjie, Sun Hui. (2021) Evaluation of business model innovation based on the entropy weight-mutation progression method—Taking JF enterprises as an example. J. Science and Technology Management Research, 41(01): 48-53.
[3] Liu Qian, Wang Xiuwei. (2020) Evaluation of the optimization and upgrading ability of the cultural industry in the Grand Canal Cultural Belt based on the entropy method-mutation progression method. J. Cultural Industry Research, (01): 195-209.
[4] Gu Yu, Wang Hehuan. (2015) Financial performance evaluation of listed companies in the logistics industry. J. Finance and Accounting Newsletter, (20): 50-53.
[5] Wang Yan. (2015) Research on Performance Evaluation of Logistics Listed Companies. D. Nanjing University of Aeronautics and Astronautics,