The Empirical Analysis about Financial Performance of SSE Company Based on PCA-Bootstrap-DEA Model

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Abstract. This paper analysis accounting indicators of all companies those trade in Shanghai Securities Exchange and explores the PCA method in order to solve the repetitiveness of information between indicators which caused by the excessive number of indicators and simplify the original indicator system structure. Then the outcomes of principal component becomes input-output indicator of the Bootstrap-DEA arithmetic. At last we obtain the “relative efficiency” of the financial performance of companies. We get the conclusion that the PCA-Bootstrap-DEA model. This paper can provide reference for improving the understanding of the financial performance of the SSE company.

Introduction

In recent years, as the country to vigorously support the financial sector, many listed companies have sprung up, competition in the financial sector has become more intense, then if a listed company wants to maintain a good competitive edge, it must have a clear understanding of the company itself. The level of financial performance is an important factor in measuring whether a company can maintain a healthy development. Therefore, this paper focuses on the research on the financial performance of listed companies, provides decision-making basis for decision-makers of enterprises, and promotes the healthy development of listed companies.

As early as 1922, the famous American economist McKinsey proposed that the evaluation of corporate performance should start from its external environment and compare the management of the enterprise with the development strategy and the level of management in peacetime through the external environment [1]. In the 1990s, Robert Kaplan and David Norton created the “balanced scorecard” approach to corporate performance evaluation [2]. In 2017, Xu Xiaofei and others used the DEA analysis method to evaluate and study the corporate performance of China's New Third Board listed companies. The research results show that the overall operating performance of the listed companies in the New Third Board is considerable, which is worthy of investors' investment and attention [3].

Summary of Related Theories

Principal Component Analysis

Principal Components Analysis (PCA) is a dimensionality reduction method, which is a multivariate statistical method that converts multiple indicators into several comprehensive indicators under the premise of little information loss. we can simplify the original index architecture and make the problem easier to improve the efficiency of analysis [4].

The Basic Principle of DEA

The Data Envelopment Analysis (DEA Model) method is an efficiency evaluation method proposed by the famous American operations researcher A. Charnes in 1978. At present, the two commonly used models of DEA are CCR model and BCC model respectively. This paper chooses the BCC model for calculation.
The BCC model assumes that there are $n$ decision units DMU, each DMU has $m$ inputs and $s$ outputs, $x_{ij}$ and $y_{ij}$ represent the $i$-th input and the $r$-th output of the $j$-th DMU, respectively, and $\lambda_j$ is for each DMU Index weight, $\sum_{j=1}^{n} x_{ij} \lambda_j$ and $\sum_{j=1}^{n} y_{ij} \lambda_j$ is the weighted DMU input and output, $\theta$ is the relative efficiency, $s^-$ and $s^+$ represents the slack variable, $\varepsilon$ represents infinity, and the target is planned as follows:

$$
\left\{ \begin{array}{l}
\min [\theta - \varepsilon (\sum_{i=1}^{m} s^-_i + \sum_{i=1}^{m} s^+_i)] \\
\sum_{j=1}^{n} x_{ij} \lambda_j + s^-_i - \theta x_{ij} = 0, i = 1, 2, ..., m \\
\sum_{j=1}^{n} y_{ij} \lambda_j - s^+_r - y_{ij} = 0, r = 1, 2, ..., s \\
\sum_{j=1}^{n} \lambda_j = 1 \\
\lambda_j , \theta, s^-_i, s^+_r \geq 0 
\end{array} \right.
$$

**DEA Model Correction Based on Bootstrap Algorithm**

Traditional DEA model is difficult to avoid the problem of sample sensitivity and extreme value because the observation sample is so limited that the measured efficiency value is limited. Kniep et al. also pointed out that the efficiency value obtained by the DEA model is actually a kind of "relative efficiency", which is a biased and inconsistent estimator relative to the absolute efficiency value [5]. For this reason, Simar and Wilson proposed the Bootstrap-DEA method to solve this drawback. The Bootstrap-DEA method uses the method of repeated self-sampling to infer the empirical distribution of DEA estimates.

**Sample Indicator Data Preprocessing**

**Indicator Selection**

This paper mainly selects 1326 listed companies in China’s SSE section as research samples. In the choice financial terminal database, the relevant financial indicators are divided into six dimensions: valuation index, solvency, operational capability, per share index, profitability and growth ability. Therefore, based on these six dimensions, this paper selects all aspects. Based on the existing research, the specific indicators are shown in Table 1.

| Input indicator | Name | symbol | Output indicator | Name | symbol |
|-----------------|------|--------|-----------------|------|--------|
| Valuation indicator | PE (TTM) | X1 | EPS | Y1 |
| | PCF(TTM) | X2 | OpeCFPS | Y2 |
| | PS (TTM) | X3 | Totopeins | Y3 |
| | Equity value | X4 | CapsurfdPS | Y4 |
| | PB (LYR) | X5 | WEPS | Y5 |
| | PCF (LYR) | X6 | WROE | Y6 |
| Solvency | Dbasrt | X7 | ROA | Y7 |
| | Equmul | X8 | Netprfrt | Y8 |
| | Indbrt | X9 | ROIC | Y9 |
| | Currt | X10 | ROE (TTM) | Y10 |
| | Cascurr | X11 | Bseapshgrrt | Y11 |
| | Qckrt | X12 | opeprgrrt | Y12 |
| Operating capacity | Accrecturnover | X13 | Toddbgrrt | Y13 |
| | Totassrat | X14 | Totassgrrt | Y14 |
| | Wrkcapturnover | X15 | Netprogrrt | Y15 |
PCA Processing of Alternative Indicators

Through the factor analysis of the alternative input and output indicators, the KMO values are 0.667 and 0.693 (greater than 0.5), and the chi-square statistic significance after the Bartlett test is 0.000 (less than 0.05). This shows that there are common factors between input and output indicators, which are suitable for PCA.

The cumulative variance contribution rate of the 6 principal components FAC1-FAC6 selected in the input index reached 89.8%, and the cumulative variance contribution rate of the 5 principal components FAC1-FAC5 selected in the output index reached 88.22%. The specific results are shown in Table 2.

| Input index | FAC1 | FAC2 | FAC3 | FAC4 | FAC5 | FAC6 |
|------------|------|------|------|------|------|------|
| Eigenvalues| 5.937| 3.301| 1.104| 1.088| 1.033| 1.007|
| Contribution rate%| 39.58| 22.01| 7.36 | 7.25 | 6.88 | 6.72 |
| Cumulative contribution rate%| 39.58| 61.59| 68.59| 76.2 | 83.09| 89.8 |

| Output index | FAC1 | FAC2 | FAC3 | FAC4 | FAC5 |
|--------------|------|------|------|------|------|
| Eigenvalues  | 6.897| 3.561| 1.388| 1.279| 1.068|
| Contribution rate% | 45.98| 23.74| 9.25 | 8.53 | 7.12 |
| Cumulative contribution rate% | 39.58| 63.32| 72.57| 81.10| 88.22|

**Empirical Results and Analysis**

In the results obtained by principal component analysis of the data, the value of some principal components is negative, which does not satisfy the requirement that the input-output variable values are positive in the DEA model. Therefore, the principal components obtained in the above are forward-processed, and the new input-output data is input into the PCA-DEA model and the PCA-Bootstrap-DEA model. Due to the excessive number of selected data listed companies (DMUs), the results are written in Table 3.

| DMU | PCA-DEA model efficiency | PCA-Bootstrap-DEA efficiency |
|-----|----------------------------|----------------------------|
|     | Technical                  | Pure technical             | Scale          | Technical                  | Pure technical | Scale |
| 1   | 0.708                      | 0.743                      | 0.953          | 0.660                      | 0.700          | 0.943 |
| 258 | 0.542                      | 0.634                      | 0.855          | 0.464                      | 0.575          | 0.807 |
| 468 | 0.614                      | 0.630                      | 0.975          | 0.542                      | 0.573          | 0.946 |
| 656 | 0.657                      | 0.666                      | 0.985          | 0.564                      | 0.604          | 0.934 |
| 809 | 1.000                      | 1.000                      | 1.000          | 1.000                      | 1.000          | 1.000 |
| 1014| 0.571                      | 0.645                      | 0.885          | 0.520                      | 0.609          | 0.854 |
| 1237| 0.737                      | 0.920                      | 0.801          | 0.677                      | 0.838          | 0.808 |
| average | 0.731                    | 0.833                      | 0.884          | 0.632                      | 0.751          | 0.850 |

According to Table 3, the average technical efficiency of SSE companies in 2018 is 0.731, and the pure technical efficiency and scale efficiency are 0.833 and 0.884, respectively. The results show that the financial performance level of SSE companies have not yet reached the effective frontier, because of the double inefficiency of pure technical efficiency and scale efficiency.

Since the results obtained by the DEA model are “relative efficiency”, in order to obtain the “absolute efficiency” of the financial performance of each listed company, this paper use MATLAB software to program the Bootstrap-DEA method, the confidence is set to 95%. The results obtained are shown in Table 4 for Bootstrap -DEA corrective efficiency. Table 4 gives the technical efficiency values of the SSE companies and the efficiency values calculated by the Bootstrap-DEA method, and also gives a 95% confidence level. It can be seen from Table 4 that the efficiency values calculated by the Bootstrap-DEA method fall within the confidence interval, which indicates that the correction results in this paper are accurate and effective.
Table 4. 2018 SSE company technical efficiency correction results (partial).

| DMU | PCA-DEA Technical efficiency | PCA-Bootstrap-DEA correction value |
|-----|-------------------------------|------------------------------------|
|     | Skewness | Lower boundary | Upper boundary |
| 1   | 0.708    | 0.660         | 0.049         | 0.604 | 0.701 |
| 258 | 0.542    | 0.464         | 0.079         | 0.402 | 0.533 |
| 468 | 0.614    | 0.542         | 0.072         | 0.496 | 0.600 |
| 656 | 0.657    | 0.564         | 0.093         | 0.495 | 0.648 |
| 809 | 1.000    | 0.826         | 0.174         | 0.731 | 0.986 |
| 1014| 0.571    | 0.520         | 0.050         | 0.475 | 0.563 |
| 1237| 0.737    | 0.677         | 0.059         | 0.616 | 0.726 |
| average | 0.731 | 0.632         | 0.098         | 0.561 | 0.720 |

According to the division method of Wilson et al [6], with the efficiency value of 0.9000 (PCA-Bootstrap-DEA) as the critical point, the pure technical efficiency and scale efficiency of 1326 SSE companies are divided according to high and low, and combined into high. There are four types of double high type, double low type, high-low type, and low-high type. The four types of frequency distribution histograms are shown in Figure 1:

![Figure 1. Four types of frequency distribution histograms.](image)

It can be seen from Table 3 and Figure 1. The first type is a double high type with pure technical efficiency and scale efficiency of more than 0.9000. There are only two such companies, indicating that most SSE companies are facing urgent need to improve their finances. The second type is a double low type with pure technical efficiency and scale efficiency of less than 0.900. 884 companies are double-low companies. The third type is characterized by a high level of technical efficiency and low scale efficiency, with a total of 48 companies. The fourth type is low-altitude with low efficiency and high scale efficiency with 392 companies.

**Conclusion**

In this paper, the results show that the technical efficiency of the SSE's financial performance level is low, mainly due to the common inefficiency of pure technical efficiency and scale efficiency. At the same time, the efficiency value after the correction by the Bootstrap method is significantly lower than that of the traditional DEA model, and the pure technical efficiency is significantly lower than the scale efficiency. This shows that if the SSE company wants to improve its financial performance level, it must start with financial management and improve the efficiency of pure technology, instead of simply increasing its investment scale. And according to the figure 1, there are only two double high type companies. This shows that the SSE company has a low level of financial resource management and lacks effective financial resource allocation, which needs further improvement.

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