An Empirical Research on Financial Performances of Information Security Concept Companies Based on the DEA Algorithm

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Abstract. According to financial indicators of inputs and outputs of 15 listed companies on cloud computing information security concepts for 5 consecutive years since 2013 and based on the DEA Algorithm, this paper compared and analyzed features of comprehensive technical efficiency & scale efficiency and pure-technology efficiency & scale efficiency. The result demonstrates a decrease in comprehensive technical efficiency & pure-technology efficiency and an increase in scale efficiency. Besides, this paper makes a conclusion that the polarization of corporate scales, technologies and comprehensive efficiency in this industry is relatively serious and puts forward relevant suggestions to improve the invalid ratio of DEA.

Introduction

The cloud computing industry chain is divided into three parts: back-end cloud computing data center construction, front-end cloud computing service and cloud security. In the era of DT, customer data is an important asset. It is an inevitable trend to protect customer data and realize cloud security. In the future, accelerating the construction of digital China and vigorously developing the information economy is the focus of informatization work.

On March 5, 2016, the outline of the 13th five-year plan for national economic and social development was formally released. The outline stated clearly that accelerate the construction of digital China, build an efficient information network, implement the national big data strategy, strengthen data security and comprehensively guarantee the security of information system. The rapid development of network information has significantly increased the demand for network security. It is necessary to improve the national network security guarantee system and strengthen the protection of important information systems and data resources, which reflects the importance of the country attaches to information security in the 13th five-year plan.

Information security will be a hot topic during the 13th five-year plan period, which also puts forward higher requirements for network security. It makes information security have long-term development potential. It is of great significance to establish a scientific performance evaluation method through a reasonable and comprehensive analysis of the information security.

The research methods of efficiency evaluation at home and abroad can be summarized as follows. Dupont analysis method (put forward by Dupont Company in 1903), Balanced Scorecard (BSC), strategic core and the strategic map invented by Robert kaplan (KaplanR. S) and David NORTON (NortonD. P) whose core contribution is to break the tradition of focusing only on financial indicators. Subject-based performance evaluation model adds such indicators as customer dimension, internal business process dimension, learning and growth dimension, which can overcome the lag of traditional financial indicators and evaluate performance from a broader field.

EVA (Economic Value Added Method, initiated by Stern Steward Consulting Company in 1991) comprehensively considers the impact of debt capital and equity capital on profits when reflecting the value creation of companies \[1\]; The Analytic Hierarchy Process (AHP), a multi-criteria decision-making method for quantitative analysis (proposed by American operational research experts in the early 1970s); In addition, there are fewer comprehensive indicators to replace the
original more indicators. The new indicators are independent from each other and can reflect as much information as possible. The application of fuzzy mathematics theory of fuzzy comprehensive evaluation method, that is, the fuzzy information through fuzzy judgment to obtain a clear evaluation method. Although these methods have their own advantages, there are some defects in performance evaluation, such as single index and strong subjectivity.

DEA (Data Envelopment Analysis) method can effectively overcome the above shortcomings. In dealing with the effectiveness of multi-output and multi-input, no weight hypothesis is needed. The evaluation is objective. It can also evaluate factors such as comprehensive efficiency, technical efficiency and scale efficiency. Samoi1enko, S. and Sei-Bryson, K.M. (2008) combined cluster analysis, DEA method and decision tree (DT) to study [2]. According to input-output efficiency analysis, the most effective companies were found as industry demonstrations. By comparing with input-output target values, we find out the gap. The index values needed to be improved were determined to achieve the optimum, so as to determine the size and the future management of the production technology level of ascension space.

This paper evaluates the overall performance of the information security company industry by DEA method, which plays a guiding role in the development of the company in the industry. It helps to find the problems and gaps in the development process, promotes the stable and healthy development of enterprise and enhances the competitiveness of the entire information security industry.

Research Methods

Basic Principles of DEA

DEA (Data envelopment analysis) has obvious advantages in dealing with input and output of multiple indicators. It is a systematic analysis method to evaluate the efficiency and benefit of decision-making units by convex analysis and linear programming, which evaluates the relative efficiency of decision-making units according to input and output indicators [3]. At present, it is widely used in various fields at home and abroad. Its evaluation method has been improved under the continuous in-depth exploration of scholars from all walks of life, which has laid the foundation for improving the evaluation of financial benefits.

DEA Model Construction

DEA model includes the data envelope analysis model of CRS and VRS (Fare, Grosskopf and Lovell constructed in 1994), which includes the calculation of technical efficiency and scale efficiency. In addition, it also includes the use of Malmquist DEA model, which uses panel data to calculate the total factor productivity change (TFP), technological progress, technological efficiency change and scale efficiency change index. The most basic model is the C2R model (A. Chames, Cooper and Rhodes proposed in 1978), which is used to calculate the relative efficiency of MIMO systems [4]. The specific algorithm principle is as follows.

There are n decision-making units (j = 1, 2,... ,n), each decision unit has the same m-item input , and the input vector is

\[ x_j = (x_{1j}, x_{2j}, \cdots, x_{mj})^T > 0, \quad j = 1, 2, \cdots, n \]  

Each decision unit has the same p-item output, and the output vector is

\[ y_j = (y_{1j}, y_{2j}, \cdots, y_{sj})^T > 0, \quad j = 1, 2, \cdots, n \]

\( x_{ij} \) Represents the input of the jth decision unit to the type i input.

\( y_{ij} \) Represents the output of the jth decision unit to the type i output.

\( v_i \) is the input weight for type i , \( u_r \) is the output weight for type r, where

\[ v = (v_1, v_2, \cdots, v_m)^T, \quad u = (u_1, u_2, \cdots, u_r)^T \]
The input synthesis value and output synthesis value of the jth decision unit are \( \sum_{i=1}^{m} v_i x_{ij} \) and \( \sum_{r=1}^{s} u_r y_{rj} \), define the efficiency evaluation index of each \( DMU_j \) decision unit:

\[
 h_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}
\]  

(3)

Limit max \( h_j \leq 1 \), the efficiency of the first decision unit \( h_l = 1 \) is the highest, and the system is relatively effective. If \( h_l < 1 \), the decision unit is not effective and the efficiency needs to be improved.

According to the analysis, the relative efficiency optimization evaluation model of the \( j_0 \) decision unit is as follows:

\[
 \begin{align*}
 \text{max } h_{j_0} &= \sum_{i=1}^{s} \mu_i y_{j_0} \\
 \sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} w_i x_{ij} &\leq 0, \quad j = 1, 2, ..., n \\
 \sum_{i=1}^{m} w_i x_{ij_0} &= 1 \\
 \mu_i, w_i &\geq 0, \quad i = 1, 2, ..., m; \quad r = 1, 2, ..., s 
\end{align*}
\]  

(4)

According to the dual theory of linear programming, the relaxation variables \( s^+ \) and residual variables \( s^- \) are further introduced into the dual model, then the constraint equation is established.

**Analysis and Evaluation of the Model**

Let the optimal solution of the above-mentioned problem be \( \lambda^*, s^*, \theta^* \), it has the following economic significance:

1. If \( \theta^* = 1 \), and \( s^* = 0, s^+ = 0 \), exists \( \mu^* > 0, \omega^* > 0 \) in the solution of the original linear programming, and its optimal value is \( h_{j_0} = 1 \). At this time, the production activities of decision units \( DMU_{j_0} \) are technology-effective and scale-effective.
2. If \( \theta^* = 1 \), \( s^* > 0 \) or \( s^+ > 0 \), the optimal value of the original linear programming \( h_{j_0} = 1 \) is called weak DEA efficiency, which does not achieve both technical efficiency and scale efficiency.
3. If \( \theta^* < 1 \), decision units \( DMU_{j_0} \) is not DEA efficient, economic activities are neither technologically efficient nor scale-effective.
4. The optimal value of \( \lambda_j \) is used to judge the scale profit of DMU. If it exists \( \lambda^*_j (j = 1, 2, L, n) \), the scale benefit will remain unchanged; if it does not exist \( \lambda^*_j (j = 1, 2, L, n) \) and \( \sum \lambda^*_j < 1 \) the scale benefit will increase; if it exists \( \sum \lambda^*_j < 1 \), the scale benefit will decrease.

**Empirical Test and Analysis of the Financial Efficiency Evaluation of Listed Companies Based on the Concept of Information Security**

**Selection of Samples and Indicators**

There are 15 information security concept listed companies in Shanghai and Shenzhen Stock Exchanges. We select the financial indicators to reflect input and output for five consecutive years from 2013 to 2017. This paper constructs a DEA-based financial efficiency evaluation model of information security concept listed companies. It evaluates the comprehensive performance of 15 listed companies' samples with multiple inputs and outputs. The data comes from Sina Finance and Economics Website of financial indicators. In the performance evaluation of DEA method, in order to objectively reflect the actual situation of the evaluation object, the principle of simplicity,
purpose and operability should be taken into account when selecting the indicators. Net profit and operating income should be selected as output indicators, and total assets and operating costs should be selected as input indicators. In the process of research, the input indices have little change. The output calculation model of DEA method is selected to study on the premise of effective scale and technical efficiency, and the return on scale remains unchanged. The multi-stage method is used to calculate loose variables, and the CCR model in the algorithm is adopted [5].

Analysis of Empirical Results

According to the performance evaluation indicators, the collected sample data were calculated and analyzed with the DEAP2.1 software. From the analysis table of the Operational Efficiency and Effectiveness of Listed Companies with Information Security Corporation of 2014-2018.

Comprehensive Technical Efficiency Analysis. Comprehensive technical efficiency is the product of pure technical efficiency and scale efficiency, which reflects the overall performance of the company. From the analysis, we can know that DEA of four companies in 2013 are all effective. Indicating that these companies have reached the optimal state in terms of asset business scale, operating efficiency and technology level. Accounting for 27% of the total sample, the comprehensive technical efficiency mean value is 0.898, which is higher than the average comprehensive technical efficiency of information security industry (0.834). In addition to the four effective DEA companies, including Aerospace Information, Netboarding Technology etc, six other companies, such as Lisichen and Greenland Technologies, are higher than the industry average. While the other nine companies are lower than the average of the comprehensive efficiency, which results in that the overall technical efficiency of the industry needs to be further improved.

In 2017, Aerospace Information, Netboarding Technology and Tolse’s DEA are still valid, accounting for 20% of the total sample. The comprehensive technical efficiency of Beixinyuan is reduced to 0.833. The average comprehensive technical efficiency is 0.860, which is lower than that of 2013. The number of companies higher than the average is reduced from 6 to 5. This shows that the efficiency of some companies has increased in the process of transformation and 10 companies are lower than the average comprehensive efficiency. The phenomenon of two-level differentiation shows that these companies have inadequate resources utilization. They can consider increasing output or reducing input, improving technology level and expanding scale effect on the basis of the existing situation to improve the overall efficiency of enterprises [6].

Pure Technical Efficiency Analysis. From the analysis, we can know that in 2013 seven companies with pure technical efficiency of RM1 are in the forefront of production technology efficiency in the information security industry. Aerospace information, cyberspace technology, Tuolsi, co-owned science and technology, Renzixing, Beixinyuan, Greenland science and technology reaching 47% of the total number of samples. The average pure technical efficiency is 0.920, indicating that the information security company has a relatively high level of pure technical efficiency. In 2017, Renzihang dropped to 0.873, Greenland Science and Technology dropped to 0.857, and the technical efficiency did not reach the optimal level. The pure technical efficiency of the remaining five companies remained at 1. Except for the improvement of MeiAbaco and Blue Shield shares, all the other companies declined. Therefore, compared with 2013, the average pure technical efficiency decreased, with a specific value of 0.883. Overall, the total number of pure technological efficiency effectors in the industry is higher, but the average value is not high and shows a downward trend, indicating that polarization is more obvious in the industry.

Scale Performance Analysis. In 2013, the scale performance of 5 companies, such as aerospace information, netstar technology, tuolsi, blue shield shares, and beixinyuan, reached DEA efficiency, accounting for 33% of the sample size. The sample average value was 0.963. Compared with 2013, the average scale performance sample in 2017 increased to 0.976, which was below the average. The average value is reduced to 3. Except for 3 companies whose scale performance is DEA effective, the remaining 12 companies are all in the scope of increasing returns to scale. Where “-” indicates that the indicator is effective without improvement; For enterprises with diminishing scale efficiency, the scale of assets should be reduced to improve the input-output efficiency. For
enterprises with increasing scale efficiency, the scale should be appropriately expanded to reduce costs and increase output to resist risks. According to the data analysis in 2016, we can draw the conclusion that the information security industry can expand its scale sustainably.

**Target Improvement Analysis.** DEA model analysis can not only indicate whether the DMU is effective, but also calculate specific improved target values for non-effective DMU. For DMU with DEA invalid, it can be improved according to the corresponding relaxation variable value to make it relatively effective. The target value and improvement index of the input and output indicators can be calculated with the DEAP2.1 software. Companies can find their improvement direction by combining the gap between the actual index and the target.

**Mean Analysis of Malmquist Efficiency Change.** Malmquist's analysis is to summarize and analyze the average value of technical changes of 15 listed information security companies for five consecutive years. The index is calculated with 1 as the demarcation line, which is greater than that of efficiency value and technology change value. The development direction is better, and less than 1 indicates that the overall efficiency value is decreasing. As shown in table, for five consecutive years, techch of Qiming stars is equal to 0.989, which means the average annual decrease of technical efficiency value is 1.1%. Techch of blue shield company is 1.016, which means the average annual increase of technical efficiency value is 1.6%. Companies in the industry can compare their own technology, efficiency and other changes to find gaps and deficiencies, put forward the corresponding countermeasures to improve competitiveness, speed up the pace and scale of development.

**Countermeasures and Suggestions**

**Moderately Expanding the Development Scale of the Company**

In recent years, the pace of mergers and acquisitions in China's information security industry has been accelerated. Listed companies constantly rely on the advantages of the capital market and improve their product lines through mergers and acquisitions to form synergies. From foreign experience, M&A events in the field of information security are more frequent. Compared with conventional practices, Symantec and other industry giants rely on continuous M&A to become bigger and stronger. We believe that the domestic listed companies have capital, customer advantage, and more strength to build the leading information security industry in China. The results show that the information security listed companies in China are in the increasing range of returns to scale. Increasing investment in assets and implementing diversification strategy are the main trends for listed companies to resist competition risks and promote their development in the international market. Under the environment of policy support and increasing market demand, the information security industry will continue to grow at a high speed in the future. However, compared with developed countries, China's information security market is still small. Its application field and penetration depth have great space. The continuous integration of cloud computing service providers with various vertical fields will open up a larger cloud computing service space. Although the security protection based on cloud services becomes more difficult, the business value of this field will also become more prominent.

**Market Segmentation and Diversification of Profit Model**

China's information security market is growing rapidly. In 2017, China's information security market will exceed US$3 billion. It is expected to reach US$4.82 billion by 2019. With a five-year compound growth rate of 14.5%, far higher than the growth rate of the global information security market. In terms of subdivision, the government (28%), telecommunications (17%) and finance (15%) are the three main downstream industries, which constitute the main source of information security customers.

Security software and security services have greater market segmentation potential. From the perspective of foreign situation, security software and security services dominate the information security market. With the maturity of China's information security market, enterprises are more
deeply aware that security cloud upgrading is imperative, and information security providers will accelerate the transformation to security cloud. Compared with traditional information security services, security cloud services follow the cloud computing model, which has the advantages of centralized integration of resources, customized services on demand, virtualization deployment, transparent services, fast response and so on.

With the explosive increase of data leakage in key areas such as government, military, finance and energy, the level of information security demand is increasing day by day. Ordinary network protection can no longer meet the requirements of high security level. The potential space of the mobile terminal information security market is estimated to be over 10 billion. It is at 30% speed every year. The security threat of smart phones is increasing. With the rapid growth of smartphone security, mobile information security has become an inevitable trend in the future security market. Maintaining the core competitiveness of the company, responding to market competition ahead of schedule, then developing new business growth points of the company.

**Improve the Level of Production Technology**

Pure technical efficiency has an important impact on the improvement of comprehensive efficiency. While expanding the scale of the company, more attention should be paid to technological progress. Only by improving both technical efficiency and scale efficiency can comprehensive efficiency be effective. The scientific and technological level of information security listed companies in China is in the stage of rapid improvement, but there is still a certain gap with the expected goal.

"2006-2020 national informatization development strategy" is proposed to implement network power strategy. By 2020, some key technologies will reach the international advanced level, which greatly enhance the international competitiveness of the information industry. It will greatly enhance the international competitiveness of the information industry and make informatization the leading force driving the modernization drive. We will strive to build an international leading mobile communication network by 2025. Achieving the strategic objectives of advanced technology, developed industry and unshakable network security. We will fundamentally change the fact that core and key technologies are controlled by others. It requires the company to increase investment in scientific research, adhere to independent research and technology introduction. Have the courage to innovate and develop distinctive products and services with high technical content. We need to build an internationally advanced and systematic system of core technologies.

The improvement of the level of science and technology cannot be separated from the improvement of the quality of talents, training and introducing innovative high-level talents. Improve the performance level of listed companies in the whole industry through reasonable mechanisms to stimulate the enthusiasm of employees. Forming a group of large transnational network and telecommunications enterprises which with strong international competitiveness.

**Conclusion**

Through the analysis of the empirical results, we have come to the conclusion that in recent years, China's information security industry has been developing rapidly in the opinion of the State Council on promoting the innovative development of cloud computing, cultivating the new format of the information industry, guiding opinions on actively promoting the "Internet + action" and "2006-2020 years of national informatization development strategy". It is concluded that the industrial structure is basically stable after the period of maturity and development. Compared with 2013, the average value of the industry's comprehensive technical efficiency and pure technical efficiency decreased in 2017, and the phenomenon of polarization was obvious. The macro-economic environment leads to high market risk and restricts the development of enterprises. In addition, the industry depression and the uncertainty brought by cross-industry market affect the efficiency of some information security listed companies, which make the comprehensive technical efficiency and pure technical efficiency decline, indicating that the management level and technical level need to be improved. Although the comprehensive performance of China's information
security listed companies is generally good, the improvement of the industry scale efficiency indicates that the development prospect has a large space for improvement. So many companies need to make improvement, with both opportunities and challenges.

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