A Study on the Performance of Digital Economy Companies based on DEA-malmquist Model

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ABSTRACT
With the third technological revolution, the invention and use of electronic computers has completely pushed human development to a new stage. the arrival of the post-2020 epidemic has accelerated the pace of digital transformation, and the digital economy has become the third largest industry after agriculture and industry, becoming the new engine of national economic development. The rise of digital economy also forces the transformation and upgrading of enterprises. This paper takes the main financial indicators of listed companies in digital economy as samples and considers DEA-malmquist index in addition to traditional CCR and BCC models to discuss the linear relationship between corporate R&D inputs and revenues. The study data are more significant and can clearly illustrate the positive linear relationship between R&D investment and revenue. It is an important reference for future strategic decisions and financial expenditure allocation of economic digital companies.

Keywords: *digital economy, deta envelopment analysis (DEA), Corporate performance, decision making*

1. INTRODUCTION

After the 20th century, the rapid development of the Internet has linked people's economic life with the network digital. Amazon, which brings convenient shopping experience, and Netflix, which provides people with entertainment, have made people rely on the digital economy for food, clothing, housing and transportation. In the face of such a booming new industry, many investors are curious to enter the game, thirsting for overnight riches [1]. Weakening the investment in technology and management of the enterprise itself, resulting in the overall inefficiency of the enterprise, or even in a state of profit and loss, cannot help but fall into a vicious circle, resulting in the imbalance of the market [2]. The digital industry occupies a non-negligible weight in the financial industry, and the high risk nature of the huge market strictly requires every business decision made by the enterprise in the development path. Thus, it is clear that in-depth research and quantitative performance assessment for digital economy enterprises have great significance.

The DEA model has been widely used in the performance appraisal of enterprises since its introduction, and has a solid theoretical foundation and a large amount of empirical evidence, and the research results are highly reliable. Past research has been devoted to theoretical analysis and macro trend forecasting. However, data analysis for enterprises has become a major blind spot with insufficient literature. The overall innovation of the industry still has to return to the individual development. This paper innovatively uses the DEA model to analyze the company's input-output performance, which intuitively shows the linear relationship between corporate inputs and outputs, it is of great significance, and offers some references for future strategic decisions and financial expenditure allocation of economic digital companies [3].

2. ANALYSIS OF DIGITAL ECONOMY INDUSTRY PERFORMANCE BASED ON DEA-MALMQUIST MODEL

2.1. Data and samples

Key financial data of 63 listed digital economy companies were collected and compiled for this study. The data period is 2019-12-31 to 2021-12-31 in order to eliminate the one-sidedness of the study results caused by the outbreak of the new crown epidemic to the greatest extent possible and to show the recent development of the industry. the main reason for discarding the data for 2019 is that the Internet, on which the digital economy industry is based, is highly turnover and time-sensitive, and

premature data do not have a high The reference value is not high. On the basis of directly considering the explicit data of R&D input and revenue output, the management expenses and R&D input are included in the input index, and the total assets and revenue are included in the output index for the consideration that the top-level decision-making and management also bring a lot of invisible value to this kind of enterprises [4].

The DEA model is not limited to the impact of a single indicator on output through a linear relationship between similar input variables and output. Malmquist index is a dynamic measure of the efficiency exhibited in different periods by adding the concept of time based on the traditional DEA model [5].

2.2. Technical efficiency analysis of traditional DEA model

The results can be divided into technical and scale dimensions, and the data results are analyzed below following a logic that starts from the factors of production [6].

Since pure technical efficiency represents the efficiency brought about by the company's system and management level, it is a measure of the impact of in when management and system on production efficiency. When pure technical efficiency = 1, it means that the invested resource input is effective at the current production scale. By screening the PEC (pure efficiency change) data of 63 companies listed in the digital economy, 8 of them have PEC=1, which reaches the optimal use of input resources. It is worth pondering that pure technical efficiency ignores the loss from the profitability problem and is at the optimal production scale by default.

In the use of PEC, treating the scale efficiency as a fixed quantity can cause errors in the results. With the data numbered 0016 and numbered 0606, it can be seen that the pure production efficiency index of company 0016 is 1, which satisfies the optimum. But SEC (Scale efficiency change) is less than 1, which is ineffective in scale efficiency and negates the premise that it is in the optimum input resource use efficiency. The pure technical efficiency (PEC) is 1, but the efficiency of resource use is not optimal. Therefore, the scale efficiency is defective, and the production efficiency is influenced by the size of the firm.

Therefore, it is necessary to introduce SEC as a variable in this stage of the analysis. As shown in Figure 1, the product of pure technical efficiency and scale efficiency is the integrated technical efficiency.

STC=PEC*SEC

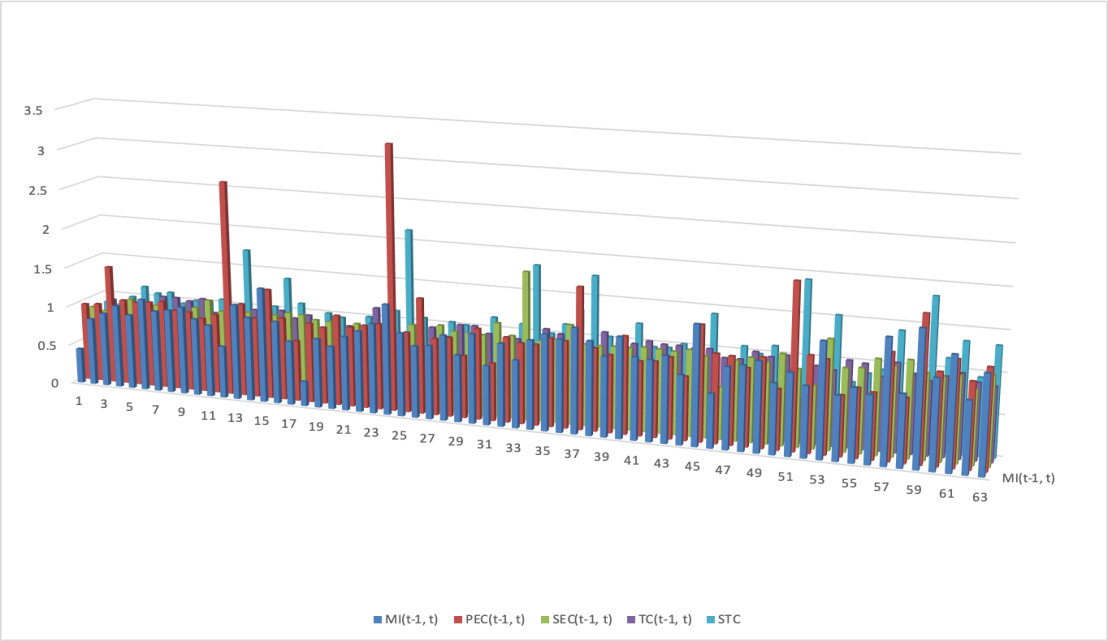

Figure 1. Decomposition results of FGLR and FGNZ of malmquist index for 63 listed companies

2.3. Analysis of malmquist index results

The malmquist index is a total factor productivity, which is the combined productivity of the production unit as a factor in the system. That is, it refers to the efficiency of production activities over a certain period of time [8]. Malmquist index looks more at the efficiency growth brought to the company by inputs other than capital and labor, such as management and innovation. This study uses panel data of different firms in different time periods to be able to measure dynamic efficiency. The calculation principle is shown in the following equations.

There are n listed companies in the digital economy with production activities in period t. X_q^t（q=1, 2, 3, 4...n) is the input value of production in period t.Y_q^t(q=1, 2, 3, 4...n) is the output. In the following equations, the numbering of q input and output indicators [9].

$$F_q^t(X_q^t,Y_q^t)=\min\theta \quad (1)$$

$$\text{s.t.}\sum_{q=1}^{n}\lambda_q X_q^t \le \theta X_{q0}^t \quad (2)$$

$$\sum_{q=1}^{n}\lambda_q Y_q^t \ge Y_{j0}^t \quad (3)$$

$$\lambda_q \ge 0,\ q=1,\ ...,\ n \quad (4)$$

Change the period t to t+1 in the above equation, i.e.

$$\sum_{q=1}^{n}\lambda_q X_q^{t+1} \le \theta X_{q0}^{t+1} \quad (5)$$

$$\sum_{q=1}^{n}\lambda_q Y_q^{t+1} \ge Y_{q0}^{t+1} \quad (6)$$

$$\lambda_q \ge 0,\ q=1,\ ...,\ n \quad (7)$$

$$M_{q0}^{t+1}\left(X_{q0}^{t+1},\ Y_{q0}^{t+1},\ X_{q0}^{t},\ Y_{q0}^{t}\right)=\left[\frac{F_{q0}^{t}(X_{q0}^{t+1},Y_{q0}^{t+1})}{F_{q0}^{t}(X_{q0}^{t},Y_{q0}^{t})}*\frac{F_{q0}^{t+1}(X_{q0}^{t+1},Y_{q0}^{t+1})}{F_{q0}^{t+1}(X_{q0}^{t},Y_{q0}^{t})}\right]^{\frac{1}{2}} \quad (8)$$

When the malmquist index > 1, it indicates an increase in efficiency relative to the previous period, and when the malmquist index < 1, it indicates a decrease in efficiency relative to the previous period. It can be used to measure the efficiency of all factors of production under different input-output ratios in different periods, and provide strong data support for the future management of the company.

According to the data in Figure 2, it is clear that 35 of the 63 companies have improved their efficiency relative to the previous period. In the above analysis, the malmquist index of enterprises in the optimal state, defined according to the integrated technical efficiency, is also at a low level.

When a company is at its best but fails to improve in efficiency, the reasons why the front and back end are at a declining level will be an important issue for the analysis below.

The efficiency of the enterprise production process, such as machinery and equipment, land, and worker labor, is regarded as a tangible asset, i.e., a gain from purely technological production. However, when pure technological production reaches its optimum, the reason for stagnation or decline in production efficiency still occurs stems from the non-specificized technological progress brought about. This is an important line of reform facing companies in the digital economy today. So the full factor rate of production is a measure of production growth that is not brought about by the growth of inputs from tangible assets.

To verify the correlation between the taken input variables and the full production factors. The correlation between the difference in overhead and R&D expenses in 2020 and 2019 was compared with the malmquist index, and companies with indexes greater than 1 and less than 1 were grouped to analyze the magnitude of the effect of both on the efficiency of the full production factor.

According to the disaggregated data, in the grouping of malmquist index >1, 22 out of 35 companies existed that reduced their overhead expenses in the set time period, accounting for about 62.8% of the total number of this grouping, which is more than half. In terms of R&D investment, 10 out of 35 companies have reduced their expenses, accounting for 28.6% of the total, which is at a low level. This shows that the increased investment in R&D expenses has a greater impact on the efficiency of all factors of production except tangible assets, especially for listed digital economy companies.

It is worth noting that when the overhead and R&D expenses are simultaneously shrunk, the efficiency gains also occur. Further analysis reveals that with malmquist index still > 1, there is only a much greater probability of negative overhead growth than negative R&D cost growth. In the case of company number 51, for example, the R&D expenses shrink by 67,411,772.37 and the overhead expenses remain positive with an all-productivity factor index of 1.00246, which is not at a higher level. The reasons for this are analyzed as follows: (1) Affected by the efficiency of economic scale. According to the scale of the company's investment in 2019 and 2020, its value is at the level of the top few percent of 63 companies, which is seen as a more mature business. For the reduction of research and development costs although to some extent shrink the malmquist index of the year, but the company's existing technology can still eliminate from this part at any time. (2) Overhead costs also have a significant positive feedback effect on companies that focus on structure. Take for example the number 51 company, which is perhaps in a phase of expansion scale growth and staff expansion. From the management's point of view, a large investment in overhead is also decisive for the future efficient development of the company.

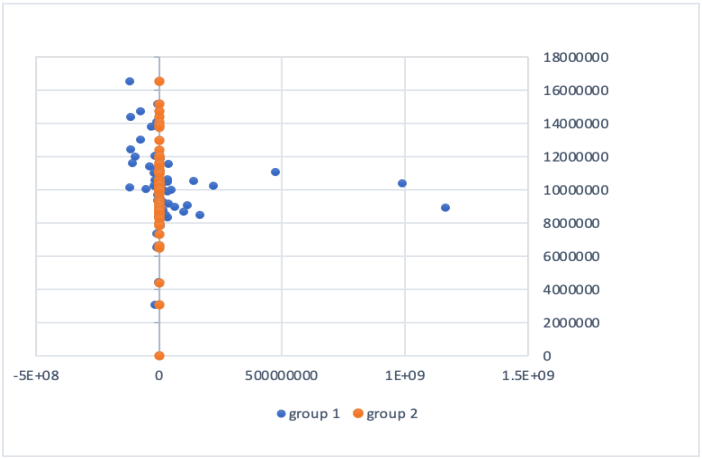

Figure 2. Scatterplot of correlation between MI index and change volume

In accordance with the above malmquist coefficient grouping in Figure 2, 28 subjects were screened out of 63 companies, accounting for about 1/3 of the total (table From the screened subjects, their two expense sizes are mostly smaller than the screening results of the above group). There are 7 groups with negative growth of overhead investment, accounting for 25%. There are 5 groups, accounting for 17%, with negative growth in R&D expenses. It can be preliminarily concluded that among the reasons for the decline of total factor productivity, the influence of the two is more or less the same, and the influence of management expenses is slightly larger [10]. Next, analyze the actual degree of impact of the two input quantities with specific data of individual cases.

The number 46 company, for example, has a negative growth in both overhead and R&D expenses, and the malmquist index is at a low level. This phenomenon is consistent with the previous general inference pattern. Company number 1, with 0.44060404, is at the lowest level of the 28 groups of screening results. Based on the above inference, the positive feedback of the malmquist index due to the upward trend of the R&D expenses of the company is reflected in the table, but the decrease in efficiency due to the reduction of overhead costs. Economies of scale in the full production factor is also a very important measurement point that needs to be decomposed in the derivation process, otherwise it will affect the final feedback of the results and cause misleading.

In this study, the DEA-malmquist index model was used to quantify the operational efficiency of the digital economy industry. The following findings were obtained by screening the financial data of 63 companies listed on the market and selecting management and R&D expenses as input quantities to verify their relationship with the production performance of the companies.

3. CONCLUSION

From an overall perspective, over half of the listed digital economy companies with full production factors are on the rise and have a huge development market. However, because the digital economy industry is in the Internet medium to rely on, it does not perform very well in terms of pure technical efficiency and scale.

In the digital economy industry, management and R&D work together in the efficiency growth of enterprises, but the efficiency growth of enterprises is somewhat more influenced by the investment in R&D and innovation. For large companies, the reduction of inputs in a short period of time does not cause a great loss of productivity, and the growth is smooth. But the innovation of technology and the strengthening of organizational management is the right way to develop the digital economy industry.

There is a lag between R&D and management investment, and the efficiency improvement cannot be accurately measured in the short term after investment. This is the limitation of this study. Although the years before and after the new crown epidemic are taken into account in the consideration of the time period, the sparse sample is still not enough to verify the accuracy of the data. In the subsequent study, the expansion of the selected sample size became the primary issue to be addressed.

In the post-epidemic era, the dependence of various industries around the world on the Internet continues to rise, and the digital economy industry has sprung up and entered a golden stage of development. Unlike traditional industries, decisions in the digital economy industry are more likely to be based on quantitative analysis of data, rational allocation of resources for management and R&D, and steady improvement of enterprises' own innovation capabilities to achieve sustainable development.

AUTHORS' CONTRIBUTIONS

This paper is independently completed by Xirui Gong.

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REFERENCES

[1] J. Haltiwanger, R. S. Jarmin, Measuring the digital economy [J]. Understanding the Digital Economy: Data, Tools and Research, 2000, pp.13-33.

[2] A. D. Borremans, I. M. Zaychenko, O. Y. Iliashenko, Digital economy. IT strategy of the company development [C] MATEC Web of Conferences. EDP Sciences, 2018, 170: 01034.

[3] Q. Wei, J. Zhang, X. Zhang, An inverse DEA model for inputs/outputs estimate [J]. European Journal of Operational Research, 2000, 121(1): 151-163.

[4] D. W. Jorgenson, Z. Griliches, The explanation of productivity change [J]. The review of economic studies, 1967, 34(3): 249-283.

[5] Y. Chen, A. I. Ali, DEA Malmquist productivity measure: New insights with an application to computer industry [J]. European journal of operational research, 2004, 159(1): 239-249.

[6] Understanding the digital economy: data, tools, and research [M]. MIT press, 2002.

[7] I. Van Beveren, Total factor productivity estimation: A practical review [J]. Journal of economic surveys, 2012, 26(1): 98-128.

[8] M. Khaksar, M. M. A. Malakoutian, Productivity evaluation for banking system in developing countries: DEA malmquist productivity index based on CCR, BCC, CCR-BCC (a case study) [J]. Eng Transactions, 2020, 1: 186.

[9] N. K. Mavi, R. K. Mavi, Energy and environmental efficiency of OECD countries in the context of the circular economy: Common weight analysis for malmquist productivity index [J]. Journal of environmental management, 2019, 247: 651-661.