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Analysis on the Efficiency of Technology Innovation of Listed Companies in China's Machinery Manufacturing Industry

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ABSTRACT

On the basis of the definition of technological innovation and efficiency, based on the DEA method, this paper takes the panel data of 20 listed companies in China's machinery manufacturing industry from 2011 to 2015 as samples, evaluating the technological innovation efficiency of listed companies in China's machinery manufacturing industry. Finally, it sums up and puts forward effective countermeasures to improve the technological innovation of listed companies in China's machinery manufacturing industry. It is hoped that it will play a guiding role in the technological innovation activities of listed companies in China's machinery manufacturing industry.

1. Introduction

In the development of the national economy, the machinery manufacturing industry is the foundation and premise, contributing to the development and progress of society, and is also an important criterion for measuring the comprehensive strength of the country. Nowadays, the globalization trend of the world economy is gradually strengthening, and China has become the center of machinery manufacturing. But at the same time, we should

also clearly see that China's machinery manufacturing industry is not strong; there are problems such as the lack of core technology, high-end products relying on imports to be controlled by people, and the ability to independently innovate. Therefore, "Made in China 2025" highlights the innovation-driven development strategy and regards innovation as its core competitiveness. In the "three-step" strategy of building a strong country, innovation plays an irreplaceable role.

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As such, technological innovation has become an important outlet for the future development of China's machinery manufacturing industry. This has directly contributed to the government's strong support and investment in technological innovation. China's manufacturing R&D expenditures and personnel input have grown substantially for many years. Even so, compared with the world's advanced level, there is still a considerable gap, the technical content has not been significantly improved, and international competitiveness is still relatively low, mainly due to the inefficiency of technological innovation. Technological innovation has its inherent laws. If resources are not allocated according to the law of technological innovation, it is often difficult to achieve success by merely increasing investment. In the process of developing the manufacturing industry, China must not only pay attention to the total investment of innovative resources, but also pay attention to its efficiency. Therefore, the correct grasp of the laws of technological innovation by the machinery manufacturing industry, grasping the direction according to the law, allocating resources and promoting innovation are essential to improve the efficiency of technological innovation.

2. The Meaning of Technological Innovation and Technological Innovation Efficiency

Technological innovation is the process of combining the existing technologies, scientifically applying the technology, absorbing relevant knowledge from new technologies, and providing products and services to the market through low cost. The most obvious feature of technological innovation is the commercialization of technological innovations. The purpose of technological innovation is to occupy a dominant position in the market and thus obtain certain benefits. The efficiency of technological innovation is actually the ratio between the resources invested and the resources produced in the process of technological innovation, that is to say, using the output of technological innovation to remove input, it can show the contribution rate of technological innovation resources to output, which is actually the efficiency of arranging technological innovation resources.

3. Technical Efficiency Evaluation of China's Machinery Manufacturing Listed Companies

3.1 Sample Data Selection

This paper takes the machinery manufacturing industry companies listed in the Shanghai and Shenzhen stock markets as the research object. The selection of samples mainly follows the following principles:

(1) Excluding companies with shorter listing years. The

research span of this paper is from 2011 to 2015. If it is listed after 2011, the company will be excluded.

(2) Eliminate companies with incomplete data. For the sake of statistical analysis, companies with any missing data are excluded.

(3) Excluding ST and ST* companies. Because these companies are in an abnormal financial situation, it will affect the correctness of the calculation results.

Manually sort the relevant data of 20 representative listed companies in the machinery manufacturing industry from 2011 to 2015. The data in this article are from the annual reports of listed companies and the website of the State Intellectual Property Office.

3.2 The Selection of input and output indicators

Regarding the investment in technological innovation activities, technological innovation activities require financial support, and at the same time, it is inseparable from the participation of personnel. Capital and labor input are the two most important aspects of technological innovation investment. For the input of these two aspects, the most commonly used indicators in previous studies are R&D (Research & Development) expenditures and R&D personnel (e.g. Pavitt & Wald, 1971; Sharma & Thomas, 2008; Shunzhong Liu & Jiancheng Guan, 2002; Bing Yan & Genfu Feng, 2006).^[1-4] In the research of this paper, two indicators of R&D expenditure and R&D personnel are also used as indicators of technological innovation investment. The most commonly used indicators for investment in technological innovation activities are the number of patent applications and the sales revenue of new products (Liu Junjie & Yuwei Fu, 2008; Xue Na, 2007; Ying Wu & Hongjin Yang, 2006; Fang Wei & Yulin Zhao, 2008).^[5-8] Among them, the sales revenue of new products mostly comes from special statistical reports issued by relevant national departments for industries or regions. But for listed companies at the micro level, the sales revenue of new products involves enterprise secrets. The sample company's annual report is generally not published separately. The micro-level data of this indicator is difficult to obtain. As a result of technological innovation, patents can directly reflect the output level of enterprise technological innovation activities. The relevant data of the enterprise patent application can be obtained conveniently in the website of the State Intellectual Property Office. Therefore, considering the scientificity and availability of data, this paper selects the number of patent applications as a measure of technological innovation output, as shown in Table 1.

3.3 Selection of evaluation methods

The Data Envelopment Analysis (DEA) method is based on Farrell's efficiency theory, a linear programming

method developed by Cooper and Rhodes (1978)^[9]. The basic principle of DEA is mainly by keeping the input or input of the decision unit (DMU) unchanged. By means of mathematical programming method, the relatively effective production frontier is determined, and each decision-making unit is projected onto the production front surface of DEA, and their relative effectiveness is evaluated by comparing the degree of decision-making unit deviating from the front surface of DEA. The basic models are mainly input-oriented scale-invariant CCR models and variable-scale BCC models. This paper uses the CCR model to measure the technological innovation efficiency of listed companies in China's machinery manufacturing industry.

3.4 Result Analysis

Based on the CCR model of DEA method, the paper uses DEAP2.1 software to measure the technological innovation efficiency of 20 mechanical manufacturing listed companies in 2011-2015. The specific results are shown in Table 1:

Table 1. Measurement results of technological innovation efficiency of listed companies in machinery manufacturing industry

| Company Name | 2011 | 2012 | 2013 | 2014 | 2015 | Mean Value |
|-------------------------|-------|-------|-------|-------|-------|------------|
| Bearing-Sci&Tech | 0.389 | 0.501 | 0.480 | 0.539 | 0.427 | 0.467 |
| GRG Banking | 0.145 | 0.384 | 0.486 | 0.328 | 0.206 | 0.310 |
| Jiangsu Shentong | 0.599 | 0.424 | 0.387 | 1.000 | 1.000 | 0.682 |
| Haiyuan Machinery | 0.297 | 0.221 | 0.274 | 0.518 | 0.471 | 0.356 |
| Yawei Corporation | 0.121 | 0.344 | 0.521 | 0.610 | 0.330 | 0.385 |
| Bosun Tools | 0.299 | 0.221 | 0.220 | 0.118 | 0.187 | 0.210 |
| Nantong Metalforming | 0.570 | 0.764 | 0.660 | 0.339 | 0.487 | 0.564 |
| HZ Advance Gearbox | 0.262 | 0.361 | 0.351 | 0.259 | 0.196 | 0.286 |
| NanFang Bearing | 0.685 | 0.464 | 0.154 | 0.236 | 0.671 | 0.442 |
| Xinzhu Corporation | 0.761 | 1.000 | 0.845 | 0.580 | 0.302 | 0.698 |
| Weihai Guangtai | 0.200 | 0.359 | 0.353 | 0.445 | 0.344 | 0.340 |
| Tech-Long | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Sunlight Corporation | 0.475 | 0.392 | 0.510 | 0.263 | 0.166 | 0.361 |
| Masterwork Group | 1.000 | 1.000 | 0.774 | 0.408 | 0.386 | 0.714 |
| Edan Instrument | 0.505 | 0.475 | 0.486 | 0.486 | 0.362 | 0.463 |
| Tofflon-Sci&Tech | 0.256 | 0.263 | 1.000 | 0.727 | 0.970 | 0.643 |
| Jinming Machinery | 0.856 | 0.388 | 0.372 | 0.772 | 0.756 | 0.629 |
| Xuzhou Handler | 1.000 | 0.633 | 0.120 | 0.298 | 0.213 | 0.453 |
| Tianguang Fire-fighting | 0.208 | 0.428 | 0.420 | 1.000 | 0.240 | 0.459 |
| Lanpec Tech | 0.208 | 0.960 | 0.748 | 0.372 | 0.560 | 0.570 |
| Mean Value | 0.492 | 0.529 | 0.508 | 0.515 | 0.464 | 0.502 |

Table 1 shows the technological innovation efficiency of the sample of 20 listed companies in the machinery

manufacturing industry from 2011 to 2015. It can be seen that the overall mean is 0.502, the overall efficiency is low, and the efficiency of technological innovation needs to be improved. Some companies have technical efficiency values of more than 0.8 or even more than 1 in some years. The technological innovation activities of these enterprises have high input-output efficiency (Tech-Long, 2011-2015; Jiangsu Shentong, 2014-2015; Masterwork Group, 2011-2012, etc.). In addition, the efficiency value of enterprises in some years is still less than 0.2, indicating that technical efficiency needs to be improved (GRG Banking, 2011; Bosun Tools, 2014-2015, etc.).

In order to more clearly describe the change of the mean value of technological innovation efficiency with time, the time trend graph of the average efficiency of technological innovation efficiency over the years is drawn as follows (Figure 1):

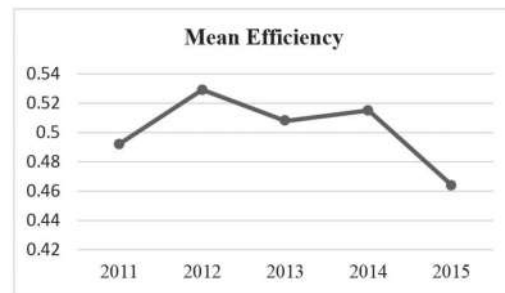


Figure 1. The time trend graph of the average efficiency of technological innovation efficiency over the years

It can be seen from Figure 1 that the average technical efficiency of the sample enterprises has generally declined during the whole period of investigation. After reaching the highest value of 0.529 from 2011 to 2012, there is a downward trend. However, there was a slight rebound in 2013-2014, but there was a significant decline in 2014 as a turning point. In the five years from 2011 to 2015, the average value of technological innovation efficiency of sample companies fluctuated around 0.5, and generally showed a state of "rise-decrease-rise-fall".

4. The Countermeasures

4.1 Realize the Mechanism Innovation and Create an Excellent Policy Environment

The government's technology investment has an extremely important impact on the efficiency and effectiveness of technological innovation of listed companies in the machinery manufacturing industry. The machinery manufacturing industry is dominated by technology research and development, and the government's technology investment has obvious market orientation for the market. Through the guidance of the government, the technical

mechanism will be innovated to ensure that the objectives of technological innovation management are more clear, decision-making is more correct, and the efficiency of technological innovation is better promoted.

The government not only needs to guide and regulate the behavior of the company, but also to intervene in a timely manner to disrupt the market order, or to have excessive competition. At the same time, it is necessary to actively encourage enterprises to carry out technological innovation and give their policy guidance so that listed companies in the machinery manufacturing industry can develop better. Encourage listed companies to apply for foreign patents, and actively build subsidiaries to achieve international technical level.

The government also needs to set up a special technology innovation fund to enable enterprises to provide sufficient funds for technology application and product development, provide loans and guarantees, and further simplify the approval process so that funds can be put in place in time. Enterprises that want to innovate in technology also need the government to further optimize tax policies. For enterprises with increased R&D investment, tax rebates can be implemented when developing new technologies and integrating production with industry, it is necessary to realize preferential policies, and encourage enterprises to innovate technologies through subsidies, financial allocations and incentives.

4.2 Transform Pure Technology Input and Realize Optimal Allocation of Resources

At present, many people think that increasing investment in technological innovation can increase the output of technological innovation. But in fact, this kind of increase in input does not necessarily increase output, mainly because of the lack of linear correlation between input and output of technological innovation. They believe that the increase in investment may result in excessive costs, and the result will be unable to make ends meet, resulting in less innovation output. For listed companies with strong machinery manufacturing, not only technological innovation and input factors are needed, but more importantly, attention is paid to the efficiency of resource allocation. Enterprises need to allocate resources according to their actual conditions and capabilities, avoid arbitrarily increasing investment, optimize the allocation of resources and factors, so that the efficiency of technological innovation can be effectively improved, and the basic innovation resources invested can guarantee good technical results. Therefore, it is necessary to actively learn from the advanced experience and development model of listed companies in the machinery manufacturing industry and become a strong company in machinery manufacturing.

4.3 Raise Awareness of Patents and Strive to Achieve Independent Innovation

The government not only needs to improve the patent system, but also the enterprise itself needs to improve the patent management system, mainly involving the use, attribution, dispute handling and rewards of property rights. At present, there are some specialized patent attorneys, agents and institutions in China's machinery manufacturing industry. However, because the machinery manufacturing industry is relatively high in technology, it is more necessary to have patent awareness.

Therefore, it is necessary for the listed companies in the machinery manufacturing industry to improve the patent agency department, strengthen the patent awareness, and actively absorb the advanced experience, so that the innovation results of the enterprise can be guaranteed, and the awareness and enthusiasm for the independent innovation of the enterprise can be better promoted, and the efficiency of technological innovation can be avoided.

4.4 Strengthen Industry-University-Research Cooperation to Achieve High-efficiency Technological Innovation

In enterprise technology innovation, the combination of industry-university-research cooperation is a very important method. That is to say, in technological innovation, listed companies need to cooperate with universities and research institutes to achieve complementary advantages, risks and interests. To achieve mutual development and achieve cooperation, technology transfer and commissioned development between listed companies and cooperative units, industry-university-research cooperation can make the technological achievements better transformed, and the scientific research results of universities can enter the market through the enterprise, so as to realize economic benefits.

Technological innovation needs to use industry-university-research cooperation as the basis and premise, and through the enterprise, through the guidance of the government, to achieve new types of cooperation. In the process of industry-university-research cooperation, the relationship between basic science, applied science, and technical research needs to be clarified. Under the circumstance of continuous cooperation between enterprise-university-research cooperation, the cooperation effect can be better and the interests of both parties can be realized smoothly.

4.5 Do a Good Job in Personnel Training and Improve the Level of Technological Innovation

In order to be successful, enterprise technology innovation must have high-quality talents as a guarantee.

People are the core of enterprise operations and the main decision-makers of technological innovation activities. Entrepreneurs need to have a certain level of innovation awareness and level, so as to be able to better influence the technological innovation and technological innovation efficiency of enterprises. Scientific and technical personnel are the main personnel of technological innovation activities and a very important part of the talent team. Enterprises should fully demonstrate the talents of science and technology personnel, and form a perfect talent introduction, training, evaluation and incentive mechanism, so that personnel can be more active and enthusiastic, so that the efficiency of technological innovation can be steadily improved. Among the various activities of the enterprise, technological innovation is the most basic, and at the same time, the technical innovation personnel need full participation and support. Therefore, it is necessary to do a good job in education and training of talents, strengthen the sense of innovation of talents, improve the overall level of scientific research personnel, and better contribute to technological innovation.

5. Conclusion

This paper applies the DEA method to empirically analyze the technological innovation efficiency of 20 representative listed companies in the machinery manufacturing industry from 2011 to 2015. Its value reflects the basic situation of the efficiency of China's manufacturing technology innovation in recent years, thus providing practical help for China to realize the grand blueprint of "Made in China 2025". The research in this paper finds that the overall level of technological innovation efficiency of listed companies in China's machinery manufacturing industry is low, and the efficiency values fluctuate around 0.5, indicating that the level of technological innovation needs to be improved. Therefore, it is necessary to optimize the entire enterprise technology innovation system from the

perspective of system engineering, thereby improving the level of technological innovation.

References

- [1] Pavitt K, Wald S. The Conditions for Success in Technological Innovation[M]. Organization for Economic Cooperation and Development, 1971.
- [2] Seema Sharma, Thomas, V. J.. Inter-country R&D Efficiency Analysis: An Application of Data Envelopment Analysis[J]. *Scientometrics*, 2008, 76(3): 483-501.
- [3] Shunzhong Liu, Jiancheng Guan. Evaluation of Innovation Performance of Regional Innovation System[J]. *China Management Science*, 2002, 10(1): 75-78. (in Chinese)
- [4] Bing Yan, Genfu Feng. Analysis of Chinese Industrial R&D Efficiency Based on Stochastic Frontier Production Function[J]. *Contemporary Economic Science*, 2006, 27(6): 14-18. (in Chinese)
- [5] Junjie Liu, Yuwei Fu. Research on Innovation Efficiency of High-tech Enterprises Based on DEA Method[J]. *Science and Technology Management Research*, 2008, (3): 11-15. (in Chinese)
- [6] Na Xue, Shudong Zhao. Evaluation of Innovation Efficiency of High-tech Industry Based on DEA——Taking Jiangsu Province as an Example[J]. *Research on Local Economic and Social Development*, 2007(5): 135-141. (in Chinese)
- [7] Ying Wu, Hongjin Yang. The Efficiency of Science and Technology Resource Allocation in High-tech Industry Based on R&D Stock[J]. *Science of Science and Technology Management*, 2006(9): 32-35. (in Chinese)
- [8] Fang Wei, Yulin Zhao. An Empirical Analysis of the Innovation Efficiency of China's High-tech Industry[J]. *Industrial Technology & Economy*, 2008, (8): 45-49. (in Chinese)
- [9] A, Cooper, W.W., Rhodes, E. Measuring the Efficiency of Decision Making Units[J]. *European Journal of Operational Research*, 1978, 2(6): 429-444.