Research on Innovation Efficiency of Listed Companies in High-end Equipment Manufacturing

Wen ZHAO¹,²,* and Yue-jiao Li²

¹Cooperative Innovation Center for Transition of Resource-based Economies, Shanxi University of Finance and Economics, Taiyuan 030006, China
²School of Management Science and Engineering, Shanxi University of Finance and Economics, Taiyuan 030006, China

*Corresponding author

Keywords: Innovation efficiency, DEA model, Malmquist index, High-end equipment manufacturing industry.

Abstract. The development of high-end equipment manufacturing industry is the embodiment of China's comprehensive national strength, and the development of high-end equipment manufacturing industry is inseparable from the improvement of the level of innovation. Through the construction of reasonable innovation input-output index system, based on the Malmquist index method, this paper makes a comprehensive evaluation of the change trend of the innovation efficiency of 22 high-end equipment manufacturing companies from 2012 to 2015, and decomposes the technological progress and technological efficiency change. Results show that: (1) There is a serious phenomenon of redundancy in the entrepreneurial activities of high-end equipment manufacturing enterprises. (2) From 2012 to 2015 years, the overall innovation efficiency of China's high-end equipment manufacturing enterprises are in the promotion, but the index of technological progress is on the decline, and the technical efficiency change index of ascension is the main reason for the current innovation to improve the efficiency of our country.

Introduction

The high-end equipment manufacturing industry is the high-end field of equipment manufacturing, and it is the high added value industry with high technology content. High-end equipment manufacturing industry is known as the sunrise industry. Its development prospects are optimistic by all countries, and all countries attach great importance to the development of high-end equipment manufacturing industry. After the rapid development in recent years, China has become a big country of equipment manufacturing. However, the independent intellectual property rights and core technologies are still under control, and the technological capabilities of major equipment production have yet to be improved. Compared with developed countries, there is still a certain gap. The low level of technological innovation is an important factor restricting the development of high-end equipment manufacturing industry in China. As the high-end equipment manufacturing industry has an important strategic position, its level of development has become the key factor that determines whether China's manufacturing industry can change from big to strong. Technology innovation is the impetus for the development of high-end equipment manufacturing industry. To make the development of high-end equipment manufacturing industry in China faster and better, it is necessary to break through the bottleneck of China's high-end equipment manufacturing industry technological innovation, and improve the level of technological innovation. It has become the consensus of high-end equipment manufacturing enterprises in China to solve the problem of big but not strong by technological innovation. However, there are still many enterprises that will increase their investment in innovation as an important way to increase innovation output. The purpose of innovation is to improve the efficiency of innovation and increase the output of innovation, rather than to fall into the "heavy input" and "light output" research and development errors. The phenomenon of high input and low production of technological innovation in China's enterprises are very common. In some enterprises, innovation has not only become the driving force
of enterprise development, but has become a burden to the consumption of enterprise resources. Innovation efficiency refers to the efficiency of resources from input to output in the process of technological innovation, which reflects the allocation of innovation resources and the contribution degree of innovation factors. Innovation efficiency is of great significance to improve independent innovation capability. If the innovation efficiency is not high, even if increase the R&D investment, it will be difficult to promote independent innovation, and it will lead to waste of innovation resources investment. On the other hand, if we can improve the efficiency of innovation, we can achieve more innovative results with less investment. Therefore, it is of great realistic significance to study the technological innovation efficiency of high-end equipment manufacturing enterprises in China.

Literature Review

Scholars in China have a short history of research on technology innovation efficiency. The research areas include regional, industrial and enterprise, especially regional and industrial level. Some scholars believe that the efficiency of regional technological innovation not only affects the balance of regional economic development, but also affects the level of technological innovation of the country, and becomes the key factor for the country to gain competitive advantage. Wang Juan (2013) used the DEA model to measure the efficiency of technological innovation in 28 provincial capitals and municipalities in China. The results show that the overall technological innovation of our cities is low and the differences between the eastern and western regions are large. Luo Ji (2013) used the stochastic frontier analysis (SFA) method to evaluate the efficiency of technological innovation in the three regions of the eastern, middle and western regions of China from 2001 to 2010. The results show that the gap of technological innovation efficiency between the three regions has expanded year by year in the past ten years. However, the research on the efficiency of technological innovation at the industrial level has mainly focused on high-tech industries and manufacturing industries. Feng Ying (2010) used the nonparametric DEA method to measure and rank the technological efficiency of the five high-tech industries in Jiangsu Province from 2003 to 2007 and conduct horizontal and vertical directions with Beijing, Tianjin, Shanghai, Zhejiang and Guangdong provinces and cities. Comparison. The conclusion shows that the input redundancy and output insufficiency coexist in the technological innovation process of high-tech industry in Jiangsu Province. Huang Xianfeng (2013) calculated the comprehensive technical innovation efficiency value, the pure technical efficiency value and the scale efficiency value of 28 industries in China's manufacturing industry by using the DEA method. And then used the optimal segmentation cluster analysis to classify 28 industries according to the efficiency value, and analyzed the difference of innovation efficiency among different industries. Compared with the regional and industrial level, there is still little research on the efficiency of technological innovation at the enterprise level. From the perspective of debt structure, Xu Yan (2016) analyzed the innovation input and innovation output efficiency of state-owned enterprises, and discussed how to promote the innovation level of state-owned enterprises from this perspective. As the high-end equipment manufacturing industry has high technology, high value-added industry characteristics, many scholars and related enterprises have realized that technological innovation plays a key role in promoting the equipment manufacturing industry to high-end development. Hu Yaohui (2013) started with the industrial technology innovation chain, explained the reasons for the low independent innovation capability of China's high-end equipment manufacturing enterprises, and put forward an effective way to promote the high-end equipment manufacturing enterprises from imitation to independent innovation. Zhao Fengyi (2012) and Shen Qing (2014) discussed the key role of technological innovation, and put forward two aspects, that is, independent innovation and external introduction, so as to improve the technological innovation capability of equipment manufacturing industry in China.

The academic circles using data envelopment analysis (DEA) method to analyze the efficiency of innovation has made gratifying achievements. The advantage of the method is that it does not need to give the weights of each index, nor does it need to give the production function of the production
frontier in advance, and it can handle multiple outputs and multiple inputs. Therefore, this method has its own unique advantages for the high-end equipment manufacturing listed company innovation analysis. However, both the CCR model and the BCC model are comparative analysis of the status of each high-end equipment manufacturing company at the same time point. In the exploration of the deep information of historical data, especially in the comparison of historical data to judge the future trend, the DEA method still has obvious shortcomings. These studies are limited to the static assessment of cross-sectional data without in-depth analysis of their dynamics. Therefore, this paper introduces the Malmquist index analysis method to empirically analyze the change of innovation efficiency of China's high-end equipment manufacturing listed companies in 2012-2015 years, in order to explore the reasons for the change of the innovation efficiency of the listed companies in the high-end equipment manufacturing industry in China, and it is helpful to better grasp the path and trend of the evolution of the innovation efficiency of high-end equipment manufacturing industry.

Index Selection and Data Description

Sample Selection

The research sample of this paper selects the listed companies in the high-end equipment manufacturing industry in Wind database concept stock. Although the new accounting standards in 2007 require listed companies to disclose R&D information, but there is no specific form of disclosure, thus increasing the difficulty of collecting data samples. There are 37 companies in the "high-end equipment manufacturing" in the Wind database concept, but after eliminating the missing information samples, the study samples of this paper ultimately have 22 listed companies.

Input and Output Indicators and Data Sources

To measure the change of enterprise innovation efficiency, the measure index should be determined according to the characteristics of enterprise innovation first. Taking into account the availability of data, we refer to the existing literature research results, and combine with the characteristics of China's high-end equipment manufacturing industry, to determine the index of technological innovation efficiency of high-end equipment manufacturing listed companies. For high-end equipment manufacturing innovation input index, we main focus on the core resource elements, specific from capital and labor two aspects to consider. Selecting research and development expenses and technical personnel to represent the capital and labor input of high-end equipment manufacturing R&D activities. Innovation output refers to the innovative achievements achieved by the economic entity through the effective development and allocation of various resources on the basis of its innovative capacity. As the direct output of innovation activities, patent is the main form of production of innovative knowledge. Therefore, the number of patent options is used as a measure of R&D innovation output. The cost of R&D and the number of technicians are from the Wind database. The number of patents is from the CSMAR database.

Table 1. Evaluation Index System of Technological Innovation Efficiency.

<table>
<thead>
<tr>
<th>input indicators</th>
<th>research and development expense[X1]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number of technicians [X2]</td>
</tr>
<tr>
<td>output indicators</td>
<td>patent number [Y]</td>
</tr>
</tbody>
</table>

Dynamic Evaluation of Technological Innovation Efficiency of Listed Companies in High-end Equipment Manufacturing Industry

Dynamic Measurement of Innovation Efficiency of Listed Companies in High-end Equipment Manufacturing Industry

We use panel data of high-end equipment manufacturing industry 22 listed companies from 2012 to
2015, and calculate the technological innovation efficiency index and its decomposition index of the listed companies in the high-end equipment manufacturing industry in the last 4 years by DEAP2.1 software, as shown in Table 2.

Table 2. Innovation efficiency index TFP and decomposition index change.

<table>
<thead>
<tr>
<th>year</th>
<th>tfpch</th>
<th>effch</th>
<th>techch</th>
<th>pech</th>
<th>sech</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012—2013</td>
<td>1.147</td>
<td>2.151</td>
<td>0.533</td>
<td>1.589</td>
<td>1.354</td>
</tr>
<tr>
<td>2013—2014</td>
<td>0.96</td>
<td>0.757</td>
<td>1.268</td>
<td>0.697</td>
<td>1.086</td>
</tr>
<tr>
<td>2014—2015</td>
<td>0.978</td>
<td>0.841</td>
<td>1.164</td>
<td>1.05</td>
<td>0.801</td>
</tr>
<tr>
<td>mean</td>
<td>1.025</td>
<td>1.111</td>
<td>0.923</td>
<td>1.052</td>
<td>1.056</td>
</tr>
</tbody>
</table>

Dynamic Analysis of Innovation Efficiency of Listed Companies in High-end Equipment Manufacturing Industry

Changes in technological innovation efficiency = change in technological progress × changes in technological efficiency. It is clear that changes in technological innovation efficiency are the result of a combination of technological change and technological efficiency change. Among them, technical efficiency change represents the change of the assessment of the management efficiency and scale efficiency, mainly reflected in the level of technological innovation activities, the level of assessment of economies of scale and economy.

(1) The analysis of technological innovation efficiency change. From the horizontal point of view, the average value of technological innovation efficiency index of these 22 listed companies in the period from 2012 to 2015 is 1.025, indicating that the efficiency of technological innovation in these enterprises has increased by 2.5% annually over the four years, mainly due to the change of technical efficiency. The technological innovation efficiency is less than the increase in technical efficiency due to the existence of technical regression (7.7% annual decline in technological progress index). This result is consistent with the current situation of China’s high-end equipment manufacturing enterprises. High-end equipment manufacturing enterprises in recent years by expanding the scale of investment and improving the management approach, enhance the technological innovation capability to a certain extent, but its real R&D capability is still not strong, and the core technology and key technologies are still heteronomy. From a vertical point of view, the technical innovation efficiency index of these 22 listed companies showed the trend of rising first and then decreasing from 2012 to 2015.

(2) The analysis of technical efficiency change. From the horizontal point of view, from 2012 to 2015, the technical efficiency index of these 22 listed companies increased by an average annual rate of 11.1%, and the average annual growth rate of its component components, pure technical efficiency index and scale efficiency index were 5.2% and 5.6% respectively. From the vertical perspective, the technical efficiency index is shifted from positive to negative in 2012-2015, which is mainly affected by the decline in pure technical efficiency and scale efficiency, mainly due to the decline in the efficiency of enterprise management, the lack of efficient use of existing innovative resources, and unreasonable allocation of factors into the proportion of each factor.

(3) The analysis of technological progress change. From the horizontal point of view, from 2012 to 2015, the average technological progress index of the 22 listed companies was 0.923, with an average annual decrease of 7.7%. Vertically, the technology progress index for high-end equipment manufacturing enterprises is rising between 2012 and 2015.

Research Conclusions and Policy Recommendations

Through the construction of reasonable innovation input-output index system, based on the
Malmquist index method, this paper makes a comprehensive evaluation of the change trend of the innovation efficiency of 22 high-end equipment manufacturing companies from 2012 to 2015, and decomposes the technological progress and technological efficiency change. The Malmquist index method generally needs to analyze the data with longer time series. Due to the short time span of empirical analysis, the results may be limited. But the empirical analysis still shows the improvement of the innovation efficiency of the listed companies in the high-end equipment manufacturing industry in China.

At present, China's high-end equipment manufacturing industry overall innovation efficiency is rising, but the gap between enterprises is relatively large, and development is very uneven. Combined with the actual situation of China's high-end equipment manufacturing enterprises, we propose the following recommendations: (1) Enterprises should adopt effective and reasonable incentive policy management strategies to make non effective enterprises effective. (2) Factor adjustment must be based on technical efficiency improvement, taking into account technological progress. (3) Enterprises should make rational use of innovation resources, optimize the input and output factors of proportion, improve the innovation output, and make the growth of enterprises from "extensive" to "intensive" in the innovative activities of high-end equipment manufacturing.

Acknowledgement
This research was financially supported by the Shanxi soft science research project under grant, no.2016041014-1, Special Funded Projects of Cooperative innovation center for transition of resource-based Economies, no. zx2017317, The research projects of the social science and humanity on Young Fund of the ministry of Education under grant, no. 12YJC630313, and Philosophy and Social Sciences Research of Higher Leaning Institutions of Shanxi under grant, no.2017326.

Reference