Research on Technological Innovation Efficiency of National High-tech Zone in Liaoning Province based on DEA Method

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Abstract: The national "14th five year plan" and the long-term goal of 2035 emphasize the implementation of innovation driven strategy, and engineering technology innovation is an important part. The National High-tech Zone has become an important carrier for Liaoning Province to implement innovation driven development strategy. Through the Three-stage DEA method and SFA regression of input and output indicators, it is found that, increasing the investment of R&D fund, the cultivation of R&D talents and the construction of R&D platform have an important impact on improving the efficiency of engineering and technological innovation, which has played an important role in improving the innovation ability of high-tech zones and promoting the economic development of Liaoning Province.

1 INTRODUCTION

China's national high-tech industrial development zone (hereinafter referred to as high-tech zone) has made important contributions to economic and social development and the construction of national innovation system. Up to now, Liaoning Province has established 8 high-tech zones. In recent years, these high-tech zones have developed rapidly in all aspects, which has played a very important role in supporting economic growth, promoting industrial upgrading and transformation, promoting scientific and technological innovation and developing strategic emerging industries. At the same time, some problems are increasingly emerging, such as the need to strengthen independent innovation capacity, insufficient R& D investment, low innovation efficiency, and uneven development between regions. Guangdong, Jiangsu and Shandong ranked the top three in the list of 31 provinces and cities GDP 2020. Comparing the national high-tech zones of Liaoning Province with Guangdong, Jiangsu and Shandong is conducive to solving the problem and promoting the further development of the high-tech zones in Liaoning Province, thus further enhancing the regional technological innovation ability of Liaoning Province and laying the driving force for economic growth.

2 LITERATURE REVIEW

The theory of innovation, first put forward by economist Schumpeter in 1912, has become a hot topic around the world. Eugene M· Roger and Judy K· Larson are the earliest scholars in foreign countries to carry out empirical evaluation of high-tech zones. Qualitative analysis and research reveal the conditions for the formation of " condensed economic effect" in Silicon Valley (Malecki 2008). Lofsten and Lindelof point out that technological innovation is indispensable to the development of science and technology parks (Lofsten 2012). TIAN L, LI Y analysis shows that foreign cooperation and technology spillover can promote the cultivation of innovative ecological efficiency in high-tech zones (TIAN 2017). In comparison, the domestic research started late, but the development trend is good. Sun Qian and Wang Xia et al respectively established the evaluation index system for evaluating the innovation ability of national high-tech zones from three modules and using factor analysis method (Sun 2018, Wang 2019). By Yang Jie et al and Yuan Hang et al, the SOM network topology model and the double difference method are used to analyze the innovation comprehensive efficiency of China's national high-tech zones (Yang 2020, Yuan 2018). Tian Zhilong et al, Xiong Bo et al, Zhang Jixin et al comprehensively

evaluated the innovation efficiency and innovation ecological efficiency of China's information technology enterprises and the carrier of high-tech zones, respectively (Tian 2019, Xiong 2019, Zhang 2019). Zheng Xuhui et al and Xiong Ran et al found the influence of trade on the innovation ecological efficiency of high-tech zones through the analysis of two-stage DEA and dynamic super-efficiency SBM model, respectively (Zheng 2018, Xiong 2019). As a result, the three-stage DEA model will further promote the economic development of Liaoning Province.

3 MEASUREMENT AND ANALYSIS OF TECHNOLOGICAL INNOVATION EFFICIENCY IN NATIONAL HIGH-TECH ZONE OF LIAONING PROVINCE

3.1 Efficiency Measurement of Technological Innovation in National High-tech Zone in Four Provinces

3.1.1 Efficiency Measures

The innovation of high-tech zone is a dynamic and complex system with multi-factor input and multi-output, which involves many inputs of human, material and financial resources in the whole process. The input index selects the full-time equivalent of R&D personnel, the number of enterprises, the internal expenditure of R&D funds, the funds for scientific and technological activities, the assets at the end of the year, the product sales income, the technical income, the patent authorization, the export earning foreign exchange and the total industrial output value as the output index.

Environmental variables are variables that are outside the observation sample and are not controlled by the sample, but have an impact on the technological innovation efficiency of the sample. When carrying out SFA modeling, the attributes and development characteristics of technological innovation in high-tech zones are taken into account, the macroeconomic environment is measured by the per capita gross domestic product (GDP) of the region, the degree of opening to the outside world is measured by the total amount of foreign direct investment, the level of scientific education in the

region is measured by the number of college students in ordinary colleges and universities, and the level of local policy support for technological innovation is expressed by the expenditure of finance on science and technology.

3.1.2 Phase I: DEA Model before Adjustment

Table 1: The First Stage Measurement of Technological Innovation Efficiency in High-tech Zone.

[1] High-tech Zones	[2] Name of Index		
	Integrated efficiency	Pure technical efficiency	Scale efficiency
Shenyang	0.315	0.392	0.805
Dalian	0.401	0.426	0.942
Nanjing	0.596	1	0.596
Suzhou	1	1	1
Guangzhou	0.45	1	0.45
Shenzhen	0.445	1	0.445
Jinan	0.459	1	0.459
Qingdao	0.469	0.675	0.695

As shown in Table 1, considering the influence of environmental factors and random factors, the average comprehensive technological innovation efficiency of Liaoning High-tech Zone in 2018 is 0.65, the average pure technical efficiency is 0.79, and the scale efficiency is 0.83. From the point of view of pure technical efficiency, Liaoning High-tech Zone is lower than the other three provinces, but the scale efficiency is generally superior to the other three provinces except Benxi Hi-tech Zone.

It can be seen from the above table that the provincial capital cities and cities with better economic development are selected from the four provinces for DEA analysis. The innovation efficiency indicators of the two cities in Liaoning Province are lower than those of the other three provinces, indicating that there is room to improve the overall innovation ability of Liaoning Province. The reason is that the economic development of Jiangsu, Guangdong and Shandong is good, and the investment in the related elements of technological innovation is much, which leads to the improvement of pure technical efficiency, but it can also reflect that the utilization rate of the elements is not enough, so the scale efficiency is low.

3.1.3 Phase II: SFA Regression Analysis

Regression found that the LR values of the five inputs were greater than the critical value, which indicated

that it was suitable for random frontier analysis. The regression coefficient of the relaxation variables of the per capita GDP to all input elements is positive, which indicates that the per capita GDP has a stimulating effect on input redundancy. It can explain that the high-tech zones in some well-developed cities in China, such as Nanjing, Guangzhou, Jinan and Qingdao, have strong economic strength, rich innovation resources and large support and investment in the high-tech zones, but because they are not properly allocated, the comprehensive efficiency of innovation technology is not high. Both the regression coefficient of regional openness to the number of enterprises in the high-tech zone and the relaxation variable of the internal expenditure of R&D funds are negative, which indicates that the more foreign capital is used in the region, the less the number of enterprises and capital investment in the high-tech zone. For example, the higher the opening degree of Suzhou and Shenzhen, the stronger the ability of the region to absorb foreign science and technology, and the faster the development of science and technology, thus reducing the number of enterprises in high-tech zones and the investment of state financial funds. With the improvement of science education level, the higher the quality of graduates, which stimulates the redundancy of enterprises in high-tech zones. The government's financial expenditure on technology innovation will reduce the manpower and capital investment of high-tech zones. The government's financial expenditure on technology innovation will reduce the manpower and capital investment of high-tech zones. For Anshan, Jinzhou, Benxi, Fuxin national high-tech zones in the development stage, the government needs more support.

3.1.4 Phase III: Adjusted DEA Model

Table 2:   The Third Stage Measurement of Technological Innovation Efficiency in High-tech Zone.

High-tech Zones	Name of Index		
	Integrated efficiency	Pure technical efficiency	Scale efficiency
Shenyang	0.999	1	0.999
Dalian	1	1	1
Nanjing	1	1	1
Suzhou	1	1	1
Guangzhou	1	1	1
Shenzhen	1	1	1
Jinan	1	1	1
Qingdao	1	1	1

The comprehensive efficiency of most high-tech zones is 1, located on the front of production, but compared with the other three provincial capital high-tech zones, the scale compensation of Shenyang National High-tech Zone is decreasing, so it is necessary to make more rational use of human and capital factors in the park, to improve the scale efficiency of high-tech zones by increasing government support, expanding the level of utilization of foreign capital, improving the quality of workers and speeding up the progress of science and technology, and to pay close attention to the utilization efficiency of resources while increasing the input factors of technological innovation.

3.2 Findings

3.2.1 In Comparison with Provincial Capitals

Shenyang, Nanjing, Guangzhou and Jinan are the provincial capitals of their respective provinces. From the above table, we can see that the scale efficiency of Shenyang Hi-tech Zone is better than that of the other three cities. From the second stage SFA regression table, we can see that the macroeconomic environment promotes the redundancy of input elements. On the other hand, the pure technical efficiency of Shenyang High-tech Zone is lower than that of the other three urban high-tech zones, for the following reasons:

Nanjing Hi-tech Zone focuses on cultivating innovative leading enterprises and promotes the development of overall technological innovation through the policies of enterprise R&D organization performance, high recognition and storage reward, industrial technological innovation alliance, R&D fee of small and medium-sized scientific and technological enterprises. Shenzhen Hi-tech Zone allows innovative subjects that meet the conditions of industrial access to temporarily change the existing building use functions for innovative activities on the premise of safe structure, good appearance, no impact on the use of surrounding buildings, no change in the main structure, and no increase in the volume ratio. The layout of Jinan Hi-tech Zone is to build a number of international scientific and technological achievements transfer and transformation centers that integrate technological achievements trading, offshore incubation, high-level talent exchange, joint tackling, enterprise investment and cooperation between industry, education and research, so as to create a new highland for export-oriented regional scientific and technological innovation and

achievements transformation, and to raise the level of open innovation and development.

For example, promoting the cooperation between enterprises and intermediary service institutions in Liaoning High-tech Zone. On the other hand, promoting the cooperation between enterprises and financial institutions such as banks, and jointly carry out services such as science and technology low interest credit, science and technology capital pool, science and technology loan discount, etc. Promote enterprises and accurately select high growth technology-based enterprises such as eagles, gazelles and unicorns, continue to carry out listing cultivation, implement reward and subsidy policies and provide full-cycle services. Promote the cooperation between enterprises and intermediaries such as securities companies and firms, accurately screen high-growth scientific and technological enterprises such as chicks, gazelles and unicorns, continue to carry out listing cultivation, implement reward and subsidy policies and provide full-cycle services, so as to continuously improve the innovation ability of national High-tech Zone in Liaoning Province.

3.2.2 In Comparison with Cities with Better Economic Development

Suzhou, Dalian, Shenzhen and Qingdao occupy an important position in the economic development of their respective provinces. It can be found that the comprehensive efficiency of Dalian Hi-tech Zone is lower than that of the other three cities, mainly due to the low efficiency of pure technology. Specifically:

Suzhou Independent Innovation Square Development Co. Ltd held 2019 science and technology service industry innovation and development exchange. By increasing the investment in science and technology activities, the exchange of science and technology service institutions, new R&D institutions, science and technology enterprises and technology brokers has been promoted, thus enhancing the technological innovation and development ability of Suzhou Hi-tech Zone. In 2019, the Shenzhen Science and Technology Innovation Commission, together with the Municipal Finance Bureau, revised the "Measures for the Management of Science and Technology Research and Development Funds in Shenzhen ", such as raising the separate amount of equipment, instruments and software purchase fees. In 2019, Huang Hai led the "National Marine Aquatic Germplasm Resources Bank" to be selected as the National Science and Technology Resources sharing Service platform. This is another national scientific

research and innovation platform added by Huang Hai after the Ministry of Science and Technology Marine Fisheries International Science and Technology Cooperation Base, Mariculture equipment and Biological breeding Technology National Local Joint Engineering Research Center (Qingdao) and so on. Dalian east of Huang Hai, west of Bohai Sea, can learn from the development of Qingdao high-tech zone to use the advantages of characteristic industries to promote the innovation of science and technology efficiency.

Increasing the precise support for scientific and technological enterprises and high-tech enterprises in the National High-tech Zone of Liaoning Province, promote transformation and industrialization of high-tech achievements, further improve the financial environment through preferential tax policies, strengthen investment attraction, and pay more attention to research and development investment. Through tax policies, increasing support for advantageous industries in Liaoning Province, further use advantageous industries to drive economic transformation and upgrading, besides, using innovation to drive the revitalization of old industrial bases, develop emerging scientific and technological innovation industries, and speed up the process of transformation of old and new kinetic energy. To strengthen the government's R&D investment, we should also pay attention to improving the sustainability of innovation investment and strengthening regional coordination and linkage, which is conducive to the realization of innovation driven development.

4 CONCLUSIONS

By using the DEA model, the external environmental factors of different regions are eliminated, and the sample data of the 19 yearbook are collected, so as to compare and analyze the gap between the 8 national high-tech zones in Liaoning Province and the advanced high-tech zones in Jiangsu, Guangdong and Shandong in terms of technological innovation efficiency. Empirical results show that: (1) after considering environmental factors, there are generally problems of redundant investment, insufficient product research and development and sales; (2) the technological innovation efficiency of 8 state-level high-tech zones in Liaoning Province is generally low, and the DEA of the first stage is not effective except Yingkou and Liaoyang high-tech zones, which reflects that the overall innovation ability of the national high-tech zones in Liaoning

Province is quite weak after the standard is advanced; (3) the overall innovation ability of the advanced high-tech zones in Jiangsu, Guangdong and Shandong is close to the of innovation and effectiveness, while the innovation ability of 8 national high-tech zones in Liaoning Province is far from the effective frontier. It is possible to establish or introduce R&D institutions with strong influence through multiple channels, encourage enterprises to combine R&D, strengthen cooperation with well-known colleges and universities inside and outside the province, and speed up the gathering of a group of highly qualified talents to enhance the ability of technological innovation. At the same time, it is necessary to clarify its own advantages, and then according to the action mechanism and influence path of relevant innovation elements, implement the differentiated innovation ability promotion strategy, promote the transformation of scientific and technological achievements and stimulate economic growth.

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