Research on Improving Strategy of Technology Innovation Capability of Equipment Manufacturing Industry in Liaoning Province

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Abstract: With the development of the economy and the advancement of technology, major enterprises are also under heavy competitive pressure while welcoming huge opportunities for development. With the improvement of the global value chain system, all industries have realized the importance of improving technological innovation capabilities. As a traditional industrial province in our country, Liaoning Province has made some progress in technological innovation in the equipment manufacturing industry, but still has the problem of weak technological innovation capabilities. This paper takes the equipment manufacturing industry in Liaoning Province as the research object. This paper summarizes and analyzes the development status and technological innovation status of the equipment manufacturing industry in Liaoning Province. The author uses the entropy method to evaluate the technological innovation capability of the equipment manufacturing industry in Liaoning Province, and compares and analyzes it from the vertical and horizontal directions. At the same time, using the means of empirical analysis, with the help of Eviews software, a multiple linear regression model was constructed to study the factors affecting the technological innovation capability of Liaoning's equipment manufacturing industry. Finally, combined with the empirical research results, the countermeasures and suggestions for improving the technological innovation capability of Liaoning's equipment manufacturing industry are put forward.

1. Introduction

Since China implements the policy of reform and opening up, our country's equipment manufacturing industry has achieved rapid development. Because our country's industrialization started later than Western developed countries, there is a clear difference in the input and output of technological innovation from Western developed countries. In recent years, our country's economic development has entered a new normal. The catch-up and rise of China's manufacturing in the global value chain has made many developed countries feel threatened, and they have adopted sanctions to restrict China's development. In the face of these international threats, our country's equipment manufacturing industry lacks the support of core technologies, leading to our country's lack of international pricing power in related fields. Therefore, our country's equipment manufacturing industry has been in a weak position...
in the global value chain for a long time, and has been restrained in development and in the dilemma of "low-end lock-in".

This paper attempts to put forward an optimization strategy for the further development of the equipment manufacturing industry in Liaoning Province based on the technological innovation of the equipment manufacturing industry in Liaoning Province. Using the entropy method, the analysis is carried out by establishing a model after collecting and sorting out specific data, and combining with the actual situation of Liaoning Province to find the main factors affecting the technological innovation capability of the equipment manufacturing industry to stimulate the vitality and potential of the enterprise market. It reflects the important role of equipment manufacturing technology innovation in economic development, promotes the further resolution of these problems, and makes contributions to the theoretical research and practice of economic development in Liaoning Province.

2. Literature Summary and Theoretical Analysis

2.1. Development Status of Equipment Manufacturing Industry in Liaoning Province

The equipment manufacturing industry refers to the general term for various manufacturing industries that provide equipment for simple production and expanded reproduction in various sectors of the national economy. It is an important foundation for the development of industry and machinery. As the core part of the manufacturing industry, the equipment manufacturing industry has a direct impact on the development level of the national economy. In recent years, the overall development of the equipment manufacturing industry in Liaoning Province is as follows: From the overall profit scale, the equipment manufacturing industry is still an important part of the total national economy of Liaoning Province. According to the data released by the Liaoning Provincial Statistical Yearbook, in 2019, the profits of the equipment manufacturing industry above designated size in Liaoning Province accounted for nearly 20% of the profits of the province's industrial enterprises; from the overall value-added scale, the scale of added value shows the development characteristics of overall stable development and partial fluctuations; from the perspective of the overall scale of enterprises, in recent years, the number of enterprises in the equipment manufacturing industry in Liaoning Province has shown a downward trend year by year.

The more an enterprise invests in technological innovation, the better the development of its technological innovation. In this paper, the author selects two indicators of R&D expenditure investment and R&D personnel investment to analyze the current status of technological innovation investment in the equipment manufacturing industry in Liaoning Province. The result is shown in Figure 1.

Figure 1 Statistics of Liaoning Province's Equipment Manufacturing Technology Innovation Input

Data source: Liaoning Province Statistical Yearbook 2010-2019
This paper analyzes the technological innovation of the equipment manufacturing industry in Liaoning Province from the two indicators of the number of scientific and technological contracts and the number of patent applications by statistically collating relevant data in the *Statistical Yearbook of Liaoning Province*. The statistical results are shown in Figure 2.

![Figure 2 Output of basic innovation achievements of equipment manufacturing industry in Liaoning Province](image)

Data source: Liaoning Province Statistical Yearbook 2010-2019

### 2.2. Evaluation of Liaoning Province's Equipment Manufacturing Technology Innovation Ability

Considering the development characteristics of the equipment manufacturing industry, this paper defines the connotation of the equipment manufacturing industry's technological innovation capability as follows: The technological innovation capability of the equipment manufacturing industry refers to the comprehensive ability of an enterprise to realize the transformation of technological innovation achievements through technological innovation funds and human resources investment, and to stimulate technological innovation investment based on the benefits brought by technological innovation achievements. It can be seen that technological innovation capability is not only affected by technological innovation input, but also by the output of technological innovation results. The constituent elements of technological innovation capability are: technological innovation input capability and technological innovation output capability. Based on this, this paper constructs an evaluation index system for the technological innovation capability of the equipment manufacturing industry, as shown in Table 1.

| Table 1 Development Evaluation Index System of Equipment Manufacturing Industry |
|-----------------------------------------------|-----------------------------------------------|
| Indicators | Connotation |
| Technical Innovation Investment Indicators | Human resource investment indicators |
| Financial resources input indicators | R&D personnel (X1) |
| Direct Output | R&D Staff (X2) |
| Indirect output | R&D Expenditure (X3) |
| Technical Innovation Output Indicators | Local Financial Allocation (X4) |
| Enterprise Technology Output Value (Y1) | Number of Invention Patents (Y2) |
| Technology Contract Amount (Y3) | Export Value of Science and Technology Products (Y4) |
This paper chooses the entropy method to evaluate the high-quality development level of the equipment manufacturing industry in Liaoning Province. It is the basic principle of entropy method to determine the objective weight according to the variability of indicators. Generally speaking, the smaller the information entropy, the greater the degree of change of the indicator, the more information it contains, and the greater the contribution to the overall indicator; vice versa. Before using the entropy method, standardization processing, translation processing, dimensionless processing, entropy processing, difference coefficient processing, and index weight calculation were implemented.

3. Empirical Research on Influencing Factors of Technology Innovation Capability of Equipment Manufacturing Industry in Liaoning Province

3.1. Model Building
This paper selects the factors that affect the technological innovation capability of the equipment manufacturing industry from four dimensions, and selects relevant indicators to express them, as shown in Table 2.

Table 2 Selection of Indicators variable for Influencing Factors of Technology Innovation Capability of Equipment Manufacturing Industry in Liaoning Province

| Variable | Indicators Selection |
|----------|----------------------|
| FDI      | Foreign direct investment |
| KF       | Export value of equipment manufacturing industry |
| GDP      | Level of economic development |
| LD       | Number of employees in the equipment manufacturing industry |
| ZF       | Government expenditure for equipment manufacturing |

Taking into account the characteristics of the equipment manufacturing industry, the relevant indicators constructed in Table 2 are incorporated into the Cobb-Douglas production function. \( Z_d \) represents the technological innovation capability of the dependent variable equipment manufacturing industry. The meanings of other indicators are shown in Table 2. The technological innovation capabilities of the equipment manufacturing industry in Liaoning Province are as follows:

\[
\ln Z_d = \ln A + \alpha_1 \ln FDI + \alpha_2 \ln KF_d + \beta_1 GDP + \beta_2 LD + \beta_3 ZF
\]

3.2. Data Source and Description
The empirical data in this paper mainly come from the Statistical Yearbook of Liaoning Province and the data published by the National Bureau of Statistics. In order to ensure the accuracy and validity of the research, the research interval selected in this paper is the relevant data indicators for the ten years from 2010 to 2019.

The data statistics and regression analysis in this paper are all carried out with the help of Eviews.

3.3. Descriptive Statistics
Through statistical analysis of related indicators, a descriptive statistical table of related indicators is obtained, as shown in Table 3.

Table 3 Descriptive Statistics

| Variable | Mean  | Standard Deviation | Minimum | Maximum |
|----------|-------|--------------------|---------|---------|
| FDI      | 253.41| 89.7               | 102.4   | 368.7   |
| KF       | 1457  | 125.6              | 587     | 1729    |
| GDP      | 24797.3| 3201.6            | 18633.2 | 28910.7 |
| LD       | 175.6 | 33.5               | 109     | 197     |
| ZF       | 1188.8| 428.6              | 248.5   | 1579.6  |

Data source: Statistical Yearbook of Liaoning Province
3.4. Empirical Analysis

In order to ensure the authenticity of the empirical results, it is necessary to test the stationarity of the data. Therefore, the author uses the ADF method to test the stationarity of the variable in this paper. The test results show that the original data are not stable, but after the second-order difference, each index shows a balance. The test results are shown in Table 4.

| Variable | ADF Value | Critical Value | P Value | Conclusion |
|----------|-----------|----------------|---------|------------|
|          |           | 1%             | 5%      | 10%        |
| Zd       | -1.2658   | -3.4457        | -2.9157 | -2.5451    | 0.5895     | unstable  |
| FDI      | -1.4721   | -3.5741        | -3.0785 | -2.5741    | 0.2574     | unstable  |
| KF       | -2.1245   | -3.6587        | -3.1245 | -2.5784    | 0.2854     | unstable  |
| GDP      | -1.5421   | -3.7421        | -3.0541 | -2.6575    | 0.2142     | unstable  |
| LD       | -1.4251   | -3.8541        | -3.9541 | -2.7751    | 0.3412     | unstable  |
| ZF       | -1.3834   | -3.7803        | -3.0164 | -2.6471    | 0.3547     | unstable  |
| Zd (1)   | -3.5207   | -2.1247        | -1.7125 | -1.5127    | 0.0032     | stable    |
| FDI (1)  | -2.5412   | -2.4512        | -1.7412 | -1.4574    | 0.0024     | stable    |
| KF (1)   | -2.1425   | -2.6254        | -2.5141 | -2.1121    | 0.2211     | unstable  |
| GDP (1)  | -3.2142   | -2.5412        | -2.1452 | -1.6453    | 0.0012     | stable    |
| LD (1)   | -5.5214   | -4.2254        | -3.5784 | -3.3214    | 0.2412     | unstable  |
| ZF (1)   | -5.1081   | -4.5479        | -4.1199 | -3.7100    | 0.0213     | stable    |
| Zd (2)   | -5.5142   | -4.5472        | -3.1541 | -3.0142    | 0.0011     | stable    |
| FDI (2)  | -5.1241   | -4.6541        | -3.5475 | -3.1452    | 0.0015     | stable    |
| KF (2)   | -5.2412   | -4.2154        | -3.8541 | -3.1542    | 0.0034     | stable    |
| GDP (2)  | -5.2142   | -4.8412        | -4.2514 | -3.7512    | 0.0028     | stable    |
| LD (2)   | -5.3541   | -4.7651        | -4.0254 | -3.8514    | 0.0019     | stable    |
| ZF (2)   | -5.2412   | -4.8514        | -4.0214 | -3.6541    | 0.0017     | stable    |

In order to further analyze the factors that affect the technological innovation capability of the equipment manufacturing industry, this paper uses the weighted least squares method for regression analysis and Eviews 6.0 for WLS regression analysis. The statistical results are shown in Table 5.

| Variable | Regression Coefficients | Standard Error | t Statistics | P Value |
|----------|-------------------------|----------------|--------------|---------|
| FDI      | 0.094253                | 0.201541       | 3.332514     | 0.0472  |
| KF       | 0.154214                | 0.224512       | 3.378541     | 0.0257  |
| GDP      | 0.124741                | 0.214512       | 3.551421     | 0.0384  |
| LD       | 0.282451                | 0.147511       | 3.254124     | 0.0221  |
| ZF       | 0.252142                | 0.221452       | 3.187541     | 0.0210  |
| C        | -3.341254               | 2.541241       | 3.542142     | 0.0354  |

AdjR²=0.987412; LogL=63.3541; F Statistics=19.74125; AIC=-4.6421576; SC=5.85723; DW=1.47531

Note: The weight adopts I/abs (resid)
From the statistical results in Table 5, it can be seen that $R^2 > 0.95$, so it can be considered that the regression effect of this paper is relatively ideal, and the regression results have certain representativeness and accuracy. At the same time, $F > 18$ further confirms that the fitting effect of this paper reflects the degree of influence of variable on the model. At the same time, the $P$ value in the regression results of all variable is less than 0.05, so it is significant. Since the DW value in the regression model belongs to the 0-2 interval, there is a positive correlation between the residual series.

In order to avoid the occurrence of "pseudo-regression" leading to deviations in the research results, it is necessary to use cointegration analysis to deal with it at this time. The statistical results are shown in Table 6.

| Variable | ADF Value | Critical Value | Statistics | Conclusion |
|----------|-----------|----------------|------------|------------|
| Y1       | -2.3415   | -3.5541        | -3.1421    | -2.4432    | 0.0041     | stable     |

It can be seen from the statistical results in Table 6 that the residual has passed the ADF stationarity test.

3.5. Discussion of Empirical Results

Through statistical analysis of the above analysis results and empirical results, combined with the theoretical analysis of Liaoning Province's equipment manufacturing technology innovation capabilities in Chapter 2, the following empirical conclusions can be drawn:

(1) Factors affecting the technological innovation capability of Liaoning's equipment manufacturing industry include foreign investment, degree of openness, external economic environment, labor input, and policy support. It can be seen from the empirical results that these four variable all have a positive effect on the technological innovation capability of the equipment manufacturing industry at a significant level of 5%.

(2) Labor input and policy support have the most significant impact on the technological innovation capability of Liaoning's equipment manufacturing industry. From the statistical results of the regression coefficients of various variable, it can be seen that the larger regression coefficients are labor input and policy support, which are 0.28 and 0.25, respectively. In addition, the regression coefficients of foreign investment, economic environment, and degree of openness are 0.09, 0.13, and 0.11, respectively, indicating that the impact of these three indicators on the technological innovation capability of Liaoning Province is relatively close.

(3) The technological innovation capability of Liaoning's equipment manufacturing industry is not only affected by the internal environment, but also by the development of the external environment.

4. Conclusions and Recommendations

From the above research results, it can be seen from the vertical comparison that the technological innovation capability of the equipment manufacturing industry in Liaoning Province has decreased significantly in recent years; the horizontal comparison shows that the technological innovation capability of the equipment manufacturing industry in Liaoning Province is far behind the domestic Other provinces. Therefore, it is necessary to take reasonable measures to enhance the technological innovation capability of the equipment manufacturing industry in Liaoning Province. This paper proposes suggestions for improving the technological innovation capability of the equipment manufacturing industry from these three aspects:

(1) Establish a diversified innovation investment system: plan to strengthen technological innovation capital investment, establish an effective mechanism to train and attract high-end R&D personnel.

(2) Improving the ability to transform technological innovation achievements: attach importance to the protection and struggle of intellectual property rights, and accelerate joint innovation between industries.
(3) Create a good economic environment for technological innovation in the equipment manufacturing industry.

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References
[1] Daqiang Guo,Ray Y. Zhong,Peng Lin,Zhongyuan Lyu,Yiming Rong,George Q. Huang. Digital twin-enabled Graduation Intelligent Manufacturing System for fixed-position assembly islands[J]. Elsevier Ltd,2020,63.
[2] Mihaela Botiș Nistoran,Gabriela Victoria Mnerie,Dumitru Mnerie. Considerations about the Organic Acids Effect on Weldings in Food Processing Industry[J]. Trans Tech Publications Ltd,2020,5968
[3] Anicia Zeberli,Gioele Casola,Sara Badr,Christian Siegmund,Markus Mattern,Hirokazu Sugiyama. Approach for Multicriteria Equipment Redesign in Sterile Manufacturing of Biopharmaceuticals[J]. Springer US,2020,15(4).
[4] JFE Steel Corporation; Patent Issued for Equipment Line For Manufacturing Heavy-Walled Steel Products (USPTO 10,562,085)[J]. Energy & Ecology,2020.
[5] Institute for Information Industry; "Base Station And User Equipment For Mobile Communication System" in Patent Application Approval Process (USPTO 20200053766)[J]. Computer Technology Journal,2020.
[6] Tangshan Shushi Hardware Tools Manufacture Co. Ltd.; "Enhanced Method And Equipment Of Forging Bow-Shape Conjointed Rake" in Patent Application Approval Process (USPTO 20200047236)[J]. Politics & Government Week,2020.