The Influence of High-tech Product Complexity on The Technological Innovation of High-tech Industry

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Abstract. With the global new round of technological revolution and industrial transformation ready, scientific and technological innovation in response to the common challenges of mankind, to achieve sustainable development plays an increasingly impotent role. High-tech industry is a highly concentrated technology and knowledge industry, is also the most development potential of the industry. This paper uses the principal component analysis method and Hausmann method to measure and estimate the technological innovation and export complexity of high-tech industry for the first time, and analyze and compare the export complexity and high-tech industry technology of high-tech products in the east, middle and west regions of China Innovation input - output status quo. This paper chooses the data of China's high-tech industry from 1998 to 2015, using STATA software for empirical analysis. The empirical results show that the export complexity of China's high-tech products can promote the technological innovation of China's high-tech industry. At the same time, it is found that the export complexity of China's high-tech products affects the technological innovation of high-tech industry through R & D internal expenses and R & D staff full-time equivalence.

1. Introduction

In recent years, China's increased investment in technological innovation, personnel training and external development has prompted China's foreign trade to shift from labor-intensive to knowledge- and technology-intensive, and to improve the quality of China's foreign trade commodities. The level of innovation ability of high-tech industries can directly reflect the level of technological innovation of a country to a certain extent. However, at present, China's high-tech industry is facing a weakening of the labor dividend, the cost of borrowing is difficult to decline, the difficulty of innovation is increasing, and the growth of demand scale is slowing down. In the international trade theory such as life cycle theory, new trade theory and endogenous growth theory, it reveals that there is a mutual promotion relationship between international trade and technological innovation and that export is an influencing factor to stimulate technological innovation. Therefore, by studying the impact of export technology complexity on technological innovation, this paper can provide reference for China to further improve export complexity and technological innovation capability and how to use export trade to stimulate China's technological innovation capability. Further solve the dilemma faced by the current development of China's high-tech industry.

2. Literature references

At present, there is little literature on the role of export complexity in technological innovation. Liang Chao uses panel data to study the complexity of export technology and the ability to innovate in technology to find that the complexity of export technology can promote technological innovation in China. [1] Guo Juanjuan and Li Ping believe that the technical complexity of export products can force export enterprises to produce technological progress, leading to continuous flow of production factors between export and non-export enterprises, so that the direction of technological progress is in constant fluctuations, and thus to economic growth. Have an effect. [2] Qiu Zhishan found that the quality of exports of all countries is improving by comparing the technological complexity of emerging countries represented by China and Brazil, Russia and India. However, the fastest progress in India stems from India's emphasis on the introduction and absorption of advanced technologies, which has formed the independent innovation capability of enterprises and is upgrading along the value chain. [3] More literature focuses on the study of the impact of exports on technological innovation. Krugman found that the lack of technological innovation in underdeveloped countries can only be technologically innovative through imitation, and advanced technology through trade with advanced countries, while developed countries In order to maintain the leading position of technology, it is necessary to maintain technological innovation. [4] Feder promotes economic growth through the discovery of a country's export trade, while the export sector promotes technological innovation in the non-export sector through technology spillovers. [5] Zou Wuying's empirical test of data from 1986 to 2004 shows that export trade has different effects on technological innovation in China's eastern, central and western regions. [6] Cao Yuping found that in China's manufacturing industry, there is a reverse effect of export technology innovation in manufacturing industry. Export trade has significantly promoted technological innovation in manufacturing industry. The independent promotion effect of R&D institutions on technological innovation is not significant but combined with export trade. The role of R&D institutions in promoting technological innovation has become significant, and this promotion has increased with the expansion of export scale. [7] Li Bing and others found that export can promote independent innovation of enterprises, especially invention patents with high technical content, and further find that exports can mainly promote independent innovation of high-tech enterprises. [8]

3. Influence of the complexity of export of high-tech industry based on panel regression on technological innovation

The definition of high-tech products in this paper uses the classification of China High-tech Industry Statistical Yearbook to classify high-tech products into pharmaceutical manufacturing, aerospace manufacturing, electronics and communication equipment manufacturing, electronic computer and office equipment manufacturing, and medical care. There are five major categories of equipment and instrumentation manufacturing.

3.1 Comprehensive indicators of technological innovation in high-tech industries

First of all, this paper uses principal component analysis to establish a comprehensive index of technological innovation in high-tech industries:

Table 1. Comprehensive indicators of technological innovation in high-tech industries

Primary indicator	Secondary indicators	Code
Technological innovation investment	R&D personnel full time equivalent	Z1
	R&D expenditure internal expenditure	Z2
	R&D expenditure internal expenditure as a percentage of main business income	Z3
	New product development funding	Z4
Technological innovation output	New product output value	Z5
	The output value of new products accounts for the proportion of total output value	Z6
	New product sales revenue	Z7
	New product sales revenue as a percentage of main business income	Z8
	Number of patent applications	Z9
	Has the patent number	Z10

KMO and Bartlett test on the data, the test results show, the KMO test value is 0.790 is greater than 0.6, which is suitable for principal component analysis. According to Bartlett's sphericity test restraint, the approximate chi-square mean and degree of freedom meet the requirements, and sig=0.000 is less than 0.05. Strong correlation is suitable for principal component analysis.

From principal component total variance interpretation, we can know that the principal components to be extracted in this paper are two, which are respectively denoted as F1 and F2, and we can know that the variance percentages of the principal components F1 and F2 are 63.227 and

17.861, respectively, that is, the principal components F1 and F2. The contribution rates to high-tech innovation were 63.227% and 17.861%, respectively.

Table 2. Principal Component Analysis After Rotation Component Matrix

	Ingredient 1	Ingredient 2
Z1	.958	-.165
Z2	.978	-.161
Z3	.215	.218
Z4	.973	-.169
Z5	.981	-.064
Z6	.373	.893
Z7	.980	-.063
Z8	.367	.900
Z9	.965	-.174
Z10	.574	.106

Table 3 Principal component analysis matrix

	Ingredient 1	Ingredient 2
Z1	0.172	-0.043
Z2	0.174	-0.04
Z3	-0.004	0.126
Z4	0.175	-0.045
Z5	0.159	0.012
Z6	-0.092	0.495
Z7	0.159	0.012
Z8	-0.094	0.499
Z9	0.175	-0.048
Z10	0.069	0.084

It can be seen from Table 2 that Z1, Z2, Z4, Z5, Z7, Z9, and Z10 have large load values on the first principal component F1, so the principal component F1 can better reflect these indicators. The indicators reflect the different aspects of technological innovation quantitatively. Therefore, we named the principal component F1 as the total scale of technological innovation in the high-tech industry; while Z3, Z6 and Z8 have larger load values on the principal component F2, the principal component F2 Can better reflect these indicators. These indicators reflect the relative characteristics of technological innovation in high-tech industries, so we named the main component F2 as the relative principal component.

From the principal component analysis matrix， we can get

$$F_1 = 0.172Z_1 + 0.174Z_2 - 0.004Z_3 + 0.175Z_4 + 0.159Z_5 - 0.092Z_6 + 0.159Z_7 - 0.094Z_8 + 0.175Z_9 + 0.069Z_{10} \quad (1)$$

$$F_2 = -0.043Z_1 - 0.04Z_2 + 0.126Z_3 - 0.045Z_4 + 0.012Z_5 + 0.495Z_6 + 0.012Z_7 + 0.499Z_8 - 0.048Z_9 + 0.084Z_{10} \quad (2)$$

The comprehensive score model can be obtained by calculating the principal component synthesis model by using the ratio of the eigenvalue corresponding to each principal component to the sum of the total eigenvalues of the extracted principal components as the weight:

$$F = 0.125Z_1 + 0.127Z_2 + 0.025Z_3 + 0.127Z_4 + 0.127Z_5 + 0.037Z_6 + 0.127Z_7 + 0.037Z_8 + 0.126Z_9 + 0.072Z_{10} \quad (3)$$

3.2 Estimation of export complexity

In order to study the impact of China's export complexity on high-tech industry technology innovation, this paper draws on Hausmann's measurement method to construct the calculation method of high-tech industry export complexity on provincial panel. The specific formula and description are as follows:

$$PRODY_i = \sum_j \frac{x_{ij}/X_j}{\sum_j\left(x_{ij}/X_j\right)} Y_j \quad (4)$$

$$EXPY_h = \sum_i \frac{x_{hi}}{X_h} PRODY_i \quad (5)$$

In the formula 4, $PRODY_i$ represents the export technical content of the i product, X_{ij} represents the export value of the j region i product, X_j represents the export value of the j region, and Y_j represents the per capita GDP of the j region.

$EXPY_h$ in Equation 5 represents the export complexity of high-tech products, x_{hi} represents the export value of i high-tech products, and X_h represents the total export value of high-tech products.

3.3 Model construction and variable description

After reading the relevant literature, this paper uses the following econometric model to empirically analyze the relationship between export complexity and technological innovation.

$$\ln F = C + \alpha lnX_1 + \beta lnX_2 + \gamma lnX_3 + \delta lnX_1 * lnX_2 + \varepsilon lnX_1 * lnX_3 \quad (6)$$

In this paper, the variables are processed logarithmically to reduce the difference of data. lnF is a comprehensive index of technological innovation in high-tech industries; C is a constant term; lnX1 is the export complexity of high-tech products; lnX_2 is the internal expenditure of R&D in high-tech industries; and lnX_3 is the full-time equivalent of R&D personnel in high-tech industries. lnX_1*lnX_2 is the cross-entry of high-tech industry export complexity and R&D internal expenditure, which reflects the complementary relationship between high-tech industry export complexity and R&D internal expenditure. If it is significant, it shows that these two variables are complementary. If it is significantly positive, it can be explained that the export complexity affects the internal expenditure of R&D through the indirect effect, and then the positive effect of the technological innovation capability of the high-tech industry. lnX_1*lnX_3 is an interaction term for the export complexity and the full-time equivalent of the R&D activity personnel, such as lnX_1*lnX_2.

3.4 STATA panel data regression results

In this paper, 25 provinces, municipalities and autonomous regions except Tibet, Gansu, Ningxia, Xinjiang, and Inner Mongolia use the China High-tech Industry Statistical Yearbook, the National Bureau of Statistics data, and the high-tech industrial technology innovation indicators and high-tech calculated in the previous article. Product export complexity was analyzed by panel data regression. Before the panel data regression was carried out for empirical analysis, due to the statistical missing data in some years, this paper used SPSS software to supplement the missing data by interpolation method and Hadri test with STATA software to perform unit root test and Hausman test on each variable. The results show that each explanatory variable is a single integer, the panel data is stable, and a fixed effect model should be used.

3.4.1 Regression result

Table 4 China's high-tech industry panel data regression analysis results

F	Coef.	t	P
X_1	0.6085954	5.97	0.000
X_2	-0.6786457	-6.03	0.000
X_3	1.634121	11.67	0.000
X_1X_2	0.0767603	6.66	0.000
X_1X_3	-0.0768181	-5.32	0.000
_cons	-6.737779	-6.79	0.000
R2-within		0.9920	
F		10461.25	
P		0.000	

From Table 4, we can get the impact model of high-tech product export complexity on high-tech industry technology innovation:

$$\ln F = -6.737779 + 0.6085954 lnX_1 - 0.6786457 lnX_2 + 1.634121 lnX_3 + 0.0767603 lnX_1 * lnX_2 - 0.0768181 lnX_1 * lnX_3 \quad (7)$$

From the analysis results, R^2=0.9921 indicates that our model fitting is better, P value=0.0000, the model is significant in general, so the model of this paper can reflect the complexity of China's high-tech product export. The actual situation of the impact of technological innovation in China's high-tech industries.

In general, under the 5% significance level, the impact of EXPY, R&D internal expenditure, R&D personnel full-time equivalent and two interactive items on high-tech industrial technology innovation can be tested. The passage of variables in empirical analysis indicates that the influence variables selected in this paper do have an impact on the technological innovation of China's high-tech industries.

4. Conclusion

The complexity of China's high-tech product exports has a significant positive impact on China's high-tech industry technology innovation. This paper further studies on how export complexity affects technological innovation and finds that the complexity of China's high-tech product exports indirectly affects technological innovation by influencing the expenditure of R&D internal funds in high-tech industries.

In the study of the impact of high-tech industry export complexity on technological innovation, due to the limitation of its own knowledge level, it is not comprehensive enough in the breadth and depth of research; on the other hand, due to the changes in the statistical caliber of China's high-tech industry, and The lack of individual years and industry data will lead to the rigor of this study. In the future research, the more reliable measurement models and analysis methods will be used to further subdivide the influencing factors, and further study on the export complexity and technological innovation of China's high-tech industries from the perspective of industry, enterprise scale and enterprise nature. Analyze from the international data level where data is available.

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