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Research on the Driving Factors of the Evolution of China's High Technology Industrial Structure

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Abstract: Based on the measure of high-tech industrial structure rationalization and the sophistication in China during 2005~2014, analyzing evolution of China's high-tech industry structure. Empirical study on the impact of China's high-tech industry structure factors by the gray correlation model. Results show that the rationalization of high-tech industrial structure has a lager correlation degree with the science and technology innovation ability, and sophistication of high-tech industrial structure has high-grade correlation with fixed asset investment, the opening degree, policy support. Therefore, the driving factors of high-tech industrial structure rationalization and the sophistication exist significant differences. In order to further promote the optimization and upgrading of high-tech industrial structure, we suggest, to distinguish the general trade and processing trade on high-tech products import and export policy; R&D and independent innovation of local high-tech enterprises need to be given more attention and support; and foreign strategy on high-tech industry should be reviewed.

Keywords: High-tech industries; Structural evolution; Rationalization; Sophistication; Driving factors

1. Introduction

Output value of high-tech industry accounts for about 20% of national GDP in 2014, high-tech industry total exports in 2013 to $560.06 billion, ranking first in the world. Practice shows that high-tech industry has a increasingly significant role in promoting the development of national economy. As industry 4.0 and “Internet +” gradually deepened, foreign capital was continuously introduced, export trade increases rapidly, science and technology level rise sharply, and development significantly speed up in high-tech industry, high-tech industrial structure evolution trend is obvious. In this context, research China high-tech industrial structure evolution trend and driving factors, not only has important practical significance to adjust the structure and promote the development of high-tech industry, but also has a certain reference significance to relevant government decision-making.

Based on the existing literature review, we found that the research of structure evolution and power factor of the high-tech industry mainly concentrated in two fields which are the qualitative analysis and macro research. Parrinello (2004)[1] believed that what affect industrial structure evolution is demand inducement in the process of conversion between different industries besides the technology and foreign trade. Zhao-yang Xie, Yong-lin Wu(2007)[2] analyzed characteristics of industry structure, ownership structure, regional structure, personnel structure, R&D structure and foreign trade structure of Beijing high-tech industry, and pointed out that Beijing should establish innovation-based strategy to develop high-tech industry. Chunxiao Feng(2009)[3] established a long-term income potential index of high-tech industry based on data of high-tech industry in China from 2003 to 2007, and analyzed its structure rationalization and sophistication degree. Zejin Liu and Dikang Li (2011)[4] thought that the influence factors of the industrial structure evolution include input, technology, economic environment and industry policy, etc. Then analysis shows that the influence factors exist regional difference and time difference through single equation panel data model. Tong-bin Zhang (2012)[5] measured the effect of fiscal and tax policy by establishing a general equilibrium model of high-tech industry, and simulated the transmission mechanism which government promotes industrial structure adjustment indirectly via promoting the development of high-tech industry. Liu X (2014)[6] found that the intensity of competition from foreign invested enterprises (FIEs) and domestic skill intensity affect industry buy and make activities. Foreign competition is positively associated with the intensity of buy activity, but negatively affects the intensity of make activity. YU Yong (2015)[7] thought RD personnel input, RD investment, foreign open degree, external technology acquisition and enterprise scale have positive relation with high-tech

industry innovation performance; Property right structure have negative relation with high-tech industrial innovation performance, non-state high-tech enterprises will be more benefit to innovation performance.

It's not hard to find from the above research results, few scholars pay attention to structure evolution in high-tech industry level, and the same lack of studying in revealing the factors on the effect of high-tech industry structure evolution. In addition, driving factors which determine the evolution of industry structure also include some special factors on the industry level, and the analysis of the industrial structure framework from the macroscopic level just ignore these factors.

2. Analysis of High-tech Industrial Structure Evolution in China

High-tech industrial structure refers to quality and quantity between the high-tech industry departments in a country or a region. Along with the social development, high technology in the previous period may be the traditional technology, replaced by higher update technology. So high-tech industry structure evolution and upgrades is essentially the same as other industrial structure evolution theory, the optimization and upgrading of high-tech industrial structure includes two aspects of rationalization and the sophistication[8].

2.1. The measurement of rationalization of high-tech industrial structure

Rationalization of high-tech industrial structure reflects the coordination degree as well as degree of effective utilization of resources between the high-tech sectors. Industrial structure rationalization used to measure by structure deviation degree, but this index ignores the importance of the various industries in the economy, at the same time, the calculation of the absolute value is inconvenience for the study, so here Theil index is used to measure rationalization degree of China's high-tech industrial structure. Reference the method of chunhui gan[9], Theil index of high-tech industry is defined as:

$$TL = \sum_{i=1}^{n} (\frac{Y_i}{Y}) \ln \left(\frac{\frac{Y_i}{L_i}}{\frac{Y}{L}} \right) \quad (1)$$

Among them, Y is output value of high-tech industry, L is workers number, i is of the latter's high-tech industry, n is number of high-tech industry departments. If high-tech industrial structure is in equilibrium, there is TL equal to 0; and this index considers the relative importance between high-technology departments and avoids the absolute value of the calculation, therefore it is a better metric for high-tech industry structure reasonable degree. Theil index is not equal to 0, which indicates that high-tech industrial structure deviate from the equilibrium state, and high-tech industry structure is not reasonable.

2.2. The measurement of sophistication of high-tech industrial structure

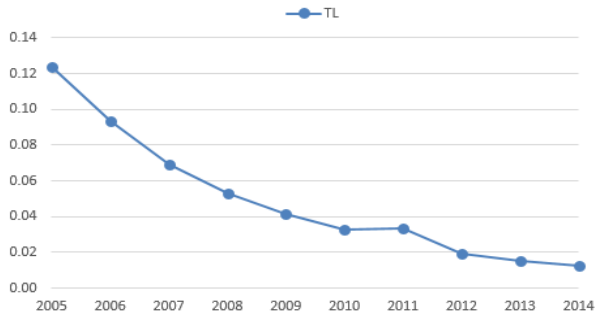
Sophistication of high-tech industrial structure refers to structure system of the high-tech industry transforms from low-level to advanced high-level[10]. Sophistication level of high-tech industry uses structure layer coefficient of high-technology industry. Reference the method of xueqing Jing[11], here high-tech industry structure layer coefficient is defined as high-tech industry is divided into sub-industries, then arranges these sub-industries from high to low level, and its proportion in high-technology industry denotes to $q(j)(0 < q(j) <= 1)$. High-tech industry structure layer coefficient can be concluded as :

$$w = \sum_{i=1}^{n} \sum_{j=1}^{i} q(j) \quad (2)$$

Obviously, the value of w is larger , the structure level of high-technology industry in a region is advanced. In theory, the minimum value is 1, the maximum is n. According to sub-industry proportions in high-technology industry, we calculate structure layer coefficient of China's high-technology industry.

2.3. Evolution analysis on high-tech industrial structure in China

From the Figure 1, the 2005~2014 changes of value w showed a greater volatility during 2005~2014. Theil indexes of high-tech industrial structure present the downward trend from 2005 to 2014, which shows high-tech industry structure tends to rationalization. The development of structure layer coefficient of high-technology industry in China can be divided into two stages: from 2005 to 2010, structure layer coefficient of high-tech industry present fluctuation change which is in rising after fall first, and this phase is a not stable stage; From 2010 to 2014, structure layer coefficient of our country high-tech industry is in upward trend after basically stable, which is the stable stage of sophistication process of high-tech industrial structure.



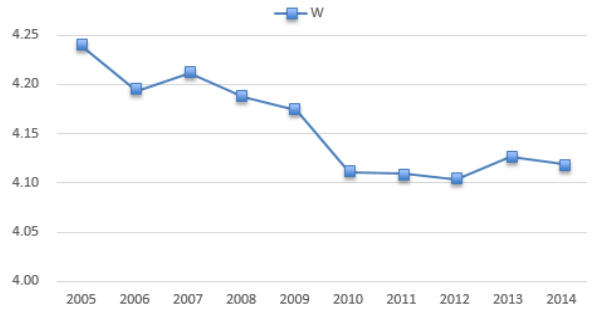


Figure 1. Structure evolution trend of high-tech industry in China from 2005 to 2014

And further pointed out that the evolution trend of TL and w is different. This means in this paper, the measure of high-tech industry structure change well distinguish the two dimensions of the rationalization and sophistication. So the interaction between two kinds of structure evolution do not need to be considered in the next empirical analysis.

3. Empirical Analysis on China's High-tech Industrial Structure Evolution

3.1. The empirical model

For the study of driving factors of high-tech industrial structure evolution in China, Theil index and layer coefficient are explained as variable coefficient, and the structure evolution factors are regard as explanatory variables. Considering the time dimension, This paper analyses China's high technology industry structure evolution by gray correlation analysis method because of less sample data. By comparing the correlation between reference sequence (high-tech industry structure index) and compare sequence (the driver factors), to identify the factors effect on the evolution of the high-tech industry structure. The basic idea of gray correlation analysis is to study corresponding relations between the factors using mathematical method which based on the data sequence of this factor. Closer it gets to the sequence curve, greater the gray correlation degree.

This article uses the Dengshi model to calculate the correlation between the sequences[12]. Model building and steps of gray correlation analysis are as follows:

1) Determining the reference sequence which reflect the characteristics of the system behavior and compare sequence which influence the system behavior. Based on the specific issues, to determine a dependent variable sequence(reference sequence) to characterize the system behavior feature, and to establish several independent variables sequences (sequence) to reflect the system behavior, which respectively to remember:

$$X_0 = \{X_0(t)\}, t = 1,2,3,\cdots n \tag{3}$$

$$X_i = \{X_i(t), t = 1,2,3,\cdots n\}, i = 1,2,3,\cdots m \tag{4}$$

Among them, n is on behalf of the reference sequence and compare sequence length, m is compare sequence number.

2) To apply dimensionless method to sequences. If you want to compare similarity between sequence geometry curve, the premise should be comparable, which requires two sequences curve has the same dimension. Dimensionless generally have two ways of initial value and the mean value. This article uses the method of initial value to apply dimensionless processing of each sequence, then get new sequence:

$$X_0 = \left\{\frac{X_0(t)}{X_0(1)}, t = 1,2,3,\cdots n\right\} \tag{5}$$

$$X_i = \left\{\frac{X_i(t)}{X_i(1)}, t = 1,2,3,\cdots n\right\}, i = 1,2,3,\cdots m \tag{6}$$

3) To figure up gray correlation coefficient of the reference sequence and comparison sequence

Correlation coefficient of the comparison and reference sequences in each moment can be calculated by the following formula:

$$\varepsilon_i(j) = \frac{\min_i \min_j |X_0(j) - X_i(j)| + \rho \max_i \max_j |X_0(j) - X_i(j)|}{|X_0(j) - X_i(j)| + \rho \max_i \max_j |X_0(j) - X_i(j)|} \tag{7}$$

ρ is distinguish coefficient, $0 < \rho < 1$, in this paper, ρ is the value of 0.5. $\min_i \min_j |X_0(j) - X_i(j)|$ is minimum two differentia. $\rho \max_i \max_j |X_0(j) - X_i(j)|$ is maximum two differential. $|X_0(j) - X_i(j)|$ is the absolute difference value of every point on the curve between the comparative sequence and the reference sequence.

4) To calculated correlation degree r_i

Correlation coefficient is the correlation value of sequence and reference sequence, in every moment, the correlation of here will figure up its average in each time as the measurement correlation degree between the sequence and the reference sequence. The correlation degree formula is as follows:

$$r_i = \frac{1}{n}\sum_{j=1}^{n} \varepsilon_i(j), i = 1,2,3,\cdots m \tag{8}$$

5) row of correlation order

According to the calculated correlation to rank. In gray correlation analysis, the correlation order is important but the size of the correlation.

3.2. Variable selection

1) Fixed asset investment. Fixed assets investment reflects the difference of structure. the capital configuration in the different high-tech departments has important influence on the formation of high-tech industry structure. Index of fixed assets investment selects fixed assets delivery utilization rate, that reflects investment benefit of high-tech industry.

2) Market factors. New product sales of high-tech industry is expressed to reflect the size of the transformation of innovation achievements into realistic productivity and acceptance by the market of high-tech industry. Demand type and quantity for high-tech product decide the type and scale of high-tech industry, and determine the means of production to reconfigure between high-tech departments, which will result high-tech industry structure to change.

3)Technical innovation ability. Technical innovation ability of high-tech industry is broken into resource input ability and output ability of technical innovation ability[13]. Indexes of resource input ability of technical innovation ability are intramural expenditure of R&D, full-time equivalent of R&D and the ratio between assimilation of technology and acquisition of foreign technology. Intramural expenditure of R&D reflects R&D investment scale of the high-tech industry. Full-time equivalent of R&D reflects the quality and quantity of personnel engaged in R&D activities. The ratio between assimilation of technology and acquisition of foreign technology reflects the process of transition from acquisition of foreign technology to independent innovation of high-tech industry, and emphasize innovation ability to evolve. In addition, patent application[14] is embodiment of independent innovation ability of which R&D ability as the core of high-tech industry. Therefore to select patent applications as index of output ability of technical innovation ability.

4) The opening to the outside world. Opening to the outside world affect the structure evolution of high-tech industry mainly by trade and foreign direct investment. This article chose new product export sales and product sales from foreign investment enterprises accounts for total industry sales to measure the degree of opening to the outside. New product export sales proportion is the ratio of new products export sales account for new product sales income, which reflects the competitiveness of new products in the international market and foreign trade of hi-tech industry. The ratio of product sales from foreign investment enterprises accounts for total industry sales reflects competition of foreign capital through market and technology spillovers of demonstration effect to our country high-tech enterprises.

5) The policy support. This indicator reflects the government's intervention and investment scale for the high-tech industry. The government through the fiscal and taxation policy support to promote production data collecting to high-tech industry, and to support, protect, guide the high-tech enterprises consciously for R&D, production according to market demand, to achieve the best benefit structure. By index of government funds accounted for science and technology activity funds said high-tech industrial structure upgrade which the government fiscal policy may lead to, with tax profit proportion reflecting the influence of tax strength on the change of high-tech industrial structure.

3.3. Data specification

Given statistics caliber consistency of China's high-tech industry , we declared the study period from 2005 to 2014. Selection of layer coefficient and Theil indexes of high-technology industry as reference sequences during 2004~2013. Raw data mainly comes from the China statistics yearbook on high technology industry (2005-2014), in which new product sales income of high-tech production convert to the comparable price based of 2004 by industrial product price index.

3.4. Empirical results

Using the above model and related data, we test driving factors of structure evolution of high-tech industry in China through the gray modeling software. Because of negative relationship between structure rationalization degree and the driving factors of high-tech industry, Reciprocal treatment to structure rationalization data of high-technology industry before test.

Dengshi gray correlation model is used to calculate the gray correlation degree, then sort them. The correlation is closer to 1 shows that the correlation is stronger. The results are shown in Table 1 and Figure 2.

TABLE 1. Gray correlation between high-tech industry structure and its driving factors

The driving factors	Rationalization		Sophistication	
	Correlation	Related orders	Correlation	Related orders
Fixed assets delivery utilization rate X1	0.6641	9	0.9954	1
New product sales X2	0.7764	4	0.8189	7
Intramural expenditure of R&D X3	0.8474	1	0.7683	9
Full-time equivalent of R&D X4	0.8313	2	0.7758	8
Ratio between assimilation of technology and acquisition of foreign technology X5	0.6812	7	0.9010	6
Patent applications X6	0.7769	3	0.6397	10
New product export sales X7	0.6606	10	0.9877	2
Government funds accounted for science and technology activity funds X8	0.6932	6	0.9412	5
Ratio of product sales from foreign Investment	0.7009	5	0.9461	4

enterprises X9				
Tax profit proportion X10	0.6698	8	0.9816	3

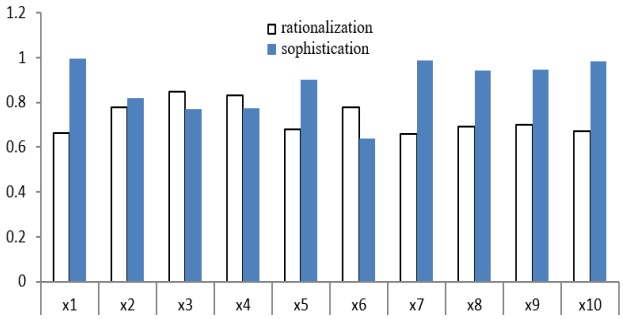


Figure 2. Gray correlation between high-tech industry structure and its driving factors

According to Table 1 and Figure 2: the main driving factor of structure rationalization of high-tech industry are Intramural expenditure of R&D (X3), Full-time equivalent of R&D (X4), patent applications (X6), new product sales income (X2). The main driving factor of structure sophistication of high-tech industry are Fixed assets delivery utilization rate (X1), Government funds accounted for science and technology activity funds (X8), tax profit proportion (X10), Ratio of product sales from foreign Investment enterprises (X9), Government funds accounted for science and technology activity funds (X8) and Ratio between assimilation of technology and acquisition of foreign technology (X5), which both in the high level of correlation, the lowest is 0.9010 and the highest is 0.9954. Can be concluded from this, the main driving factors of structure rationalization and sophistication exist significant differences. Therefore, analyzing the driving factors of high-tech industrial structure evolution shall start form two dimensions of rationalization and sophistication respectively.

3.5. Analysis of driving factors of high-tech industrial structure rationalization

Intramural expenditure of R&D, Full-time equivalent of R&D, patent applications have important influence on structure rationalization of high-tech industry, which shows that technology innovation ability is the fundamental power of high-tech industrial structure rationalization. Therefore, high-tech industrial structure rationalization must have the support of technology innovation ability. First of all, the emergence of new technology will birth the new high-tech industry, transform and eliminate of the backward high-tech industry, which will change high-tech industry structure. Second, high-tech sectors have corresponding technical conditions, technological breakthroughs and the wide application of high technology of a department can cause changes in the structure of this department and relevant departments. Secondly, the technology diffusion and infiltration can effectively promote technology change of high-tech industry. In addition, technology level decides comparative productivity differences between high-tech industry departments, leading industry with advanced technology absorb a large number of innovations, then their productivity is rising, which make the production resources transfer from department which has relatively low labor productivity to the department of comparative high labor productivity[15]. Technological innovation promotes production resources to allocate reasonably between the high-tech departments, and strengthen the coordination between sectors, which is characteristic and symbol of high-tech industrial structure evolution to the rationalization.

Market factor is represented by new product sales income also close to high-tech industrial structure rationalization, that market demand determines configuration of resources in the high-tech industry, and decides the necessity of the high-tech industry. Therefore, the change of market demand is the immediate cause of the change of the high-tech industrial structure. Demand type and size of high-tech products decide type and quantity of high-tech industries, and also decide reconfiguration of production resource between in the high technology industry. New product export sales proportion has a minimum influence for high-tech industrial structure rationalization, which shows that our country should be devoted to adjust the structure of the export, and improve the export level. Due to the restrictions of technical factors, most of the goods produced by high-tech enterprises in our country are still in labor-intensive products or agent products.

Effects of government funds accounted for science and technology activity funds and tax profit proportion are small, which shows support dynamics of the government's policy weakened with the increase of technological innovation ability. With the progress of technology and the improvement of independent innovation capacity, the role of government intervention in the allocation of resources between different departments drops off, and abilities of development and effective utilization of resources are in growing, to promote high-tech industrial structure to rationalize the evolution.

3.6. Analysis of driving factors of high-tech industrial structure sophistication

Fixed assets delivery utilization rate has the greatest effect in the sophistication of high-tech industrial structure, which shows that sophistication of high-tech industrial structure mainly depends on the fixed asset investment, and the necessary scale of fixed assets is the necessary conditions of sophistication. China's high-tech industry belongs to the technology and capital intensive industry,

of which the flow of the investment directly impact on the production and supply of high-tech products. High-tech enterprises get technology spillovers by the construction of infrastructure and upgrading, which take high-tech industry continuously adapt to market changes.

Government funds accounted for science and technology activity funds and tax profit proportion has a big impact on high-tech industrial structure sophistication. In fact, Government intervenes resources configuration between high-tech departments by economic lever and administrative means; tax is the main source of government revenue, and is an important method of the government macroeconomic regulation. Government supports or restricts the development of high-tech department through tax, to offset and correct market mechanism errors, and enhance the reasonable allocation of resources.

New product export sales and ratio of product sales from foreign Investment enterprises reflect that the international competitiveness of high-tech products and foreign investment scale is significant. New product export is one of the leading direction of high-tech industry, foreign trade by the amount and type of export commodities affects the demand of the high-tech market. Relative to the domestic enterprises, foreign enterprises is more sensitive to the international market demand, and have high production efficiency pursued by the interests, which indirect influence high-tech industrial structure evolution.

That technical innovation ability has small contribution to high-tech industrial structure sophistication shows it has no proper role in the process of evolution. There are mainly three shortcomings: firstly, the entry extent of foreign capital in high-tech industry is huge, high-tech foreign companies in China are lack of willingness to R&D and innovation. Foreign companies with core technology occupy the demand share of domestic companies, which requires domestic high-tech enterprises to pay more cost of technological innovation; secondly, its uncertainty and high risks, and the transient of technological innovation life cycle, which cause part of high-tech enterprises don't want to risk to do technological innovation. All of these affect the innovation power of domestic high-tech enterprises; thirdly, new high-tech products export in China mainly depends on foreign-funded enterprises and processing trade, which caused the effect of R&D ability of high-tech industry oriented by technology for its industrial structure sophistication is relatively small.

4. Conclusions and Recommendations

This paper think the evolution of high-tech industrial structure includes two aspects of rationalization and the sophistication. We analyze evolution of China's high-tech industry structure and its driving factors based on the data during 2005~2014. Evolution of rationalization and sophistication of high-tech industrial structure in China is not going smoothly, and driving factors of structure rationalization and sophistication have quite different effects in the high-grade evolution. The research shows that the rationalization of high-tech industrial structure has a lager correlation degree with the science and technology innovation ability, and sophistication of high-tech industrial structure has high-grade correlation with fixed asset investment, the opening degree, policy support. Through the depth analysis, we formed the following main conclusions.

Technology innovation ability is the fundamental power of high-tech industrial structure rationalization. Technological innovation promotes production resources to allocate reasonably between the high-tech departments, and strengthen the coordination between sectors, which is characteristic and symbol of high-tech industrial structure evolution to the rationalization. Market factor also close to high-tech industrial structure rationalization, that market demand determines configuration of resources in the high-tech industry, and decides the necessity of the high-tech industry. And with the progress of technology and the improvement of independent innovation capacity, the role of government intervention in the allocation of resources between different departments drops off.

Sophistication of high-tech industrial structure mainly depends on the fixed asset investment, and the necessary scale of fixed assets is the necessary conditions of sophistication. Government intervenes resources configuration between high-tech departments by economic lever and administrative means. At the same time, the international competitiveness of high-tech products and foreign investment scale is significant for evolution of high-tech industrial structure. But technical innovation ability has no proper role in the process of evolution, which leads to slow process of high-tech industrial structure sophistication.

So policy-making by the government should emphasizes high-tech industrial structure rationalization, and also need to promote high-tech industrial structure sophistication, which high technology industry development can be added power through rationalization adjustment of industrial structure, and avoid the inhibitory effect by the sophistication of high-tech industrial structure. At present our country is faced with the key phase to a higher development of high-tech industry, the high-tech industrial structure rationalization and the sophistication are facing the the urgent problems. So this paper put forward two suggestions combined with the analysis: first, rationalization of high-tech industrial structure should be placed on more important position. The key to promote the structure rationalization is attaching great importance to technological innovation ability, and emphasis on independent innovation. R&D and independent innovation of local high-tech enterprise need to be given more attention and support. Local high-tech enterprises are the backbone

which will support national high-tech industry. Independent innovation is the core of the high-tech industry, internal R&D spillover of high-tech enterprises affect industrial structure change, and adjust the industrial structure to a more rational direction. Second, policy for the sophistication of high-tech industry structure focus on fixed asset investment and trade policy. In high-tech products trade policy, it is necessary to distinguish between general trade and processing trade. Products produced in labor-intensive production processing or agent export processing appropriately reduce privilege, and import products which of processing trade category need an independent policy arrangement, to differ from general trade. In addition, the government should strictly limit redundant construction of the fixed assets and infrastructure, to avoid capital to promote low level adjustment of industrial structure adjustment.

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