The Diversity, Specialization of High-tech Industrial Structure And Economic Growth in China

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This paper measures diversity and specialization of China's high-tech industrial structure using Herfindahl-Hirschman Index, Shannon-Wiener Index and Kullback-Leibler Divergence. It will analyze the linear and non-linear relationships between them and economic growth. It will also examine the impacts of the high-tech service sector, manufacturing sector, and the scale of high-tech enterprises on growth. It has been found that there is a U-shaped non-linear relationship between the internal structure of high-tech industry and growth, based on provincial panel data. Secondly, the differentiation of high-tech industrial structure on the national-level and regional-level significantly promotes growth; therefore different optimal structures should be formed among all provinces. Thirdly, the high-tech service sector which is conductive to growth should be encouraged to develop. Lastly, to some extent, large and medium-sized high-tech enterprises have negative impacts on growth, and the development of medium and small-sized high-tech enterprises should be supported.

INTRODUCTION

China's economy has entered a new normal to adjust the industrial structure and transform the momentum of economic growth; therefore it is of practical significance to study the relationship between the industrial structure and the momentum of economic growth. The economists emphasizing the structural analysis think that the evolution of the industrial structure is the impetus of economic growth due to technological innovation leading to the process of industry replacement. Economic growth is essentially the growth of the total by promoting the change of industrial structure. In recent years, China's economic growth has proven that rapid economic growth is always accompanied with upgrading changes in the industrial structure. Production factors continue to shift from low value-added industries to high value-added industries. At present, China has entered a phase in a shift in the growth speed and the growing pains of structural adjustment. Thus it is urgent to explore the theory of relationship between industrial structure and the dynamics of economic growth to guide industrial layout adjustment. High-

tech industry has become a new economic growth goal, but the relationship between the internal structure of high-tech industry and the momentum of economic growth is still worthy of further study. With the role of technological innovation in promoting the upgrading of industrial structure and economic growth, it has received more and more attention. High-tech industry closely related to technological innovation has become the focus of attention. To vigorously develop the high-tech industry has become a strategic consensus in central government and local governments. However, in the process of high-tech industry development, there are still some important structural problems that need to be discussed. First, how should China's high-tech industry develop along with specialization and which diversification path? Second, with the strong momentum of development, there is obvious convergence between central and local governments on high technology industry development. Is this conducive to economic growth? Third, how does it affect economic development and what is the proportion between manufacturing industry and service industry in high-tech industry? Fourth, which scale formation is more favorable for high-tech enterprises?

LITERATURE REVIEW

There are two kinds of representative views on the external characteristics of the industrial structure. One is Marshall[1], Arrow[2] and Romer[3], named the "MAR externality." This point of view thinks that the specialized industrial structure will promote knowledge spillover. Similar enterprises between geographic and functional are more prone to learning and innovation. Production goods are more concentrated and efficient which can reduce cost of supply. The other one is represented by Jacobs [4] named "Jacobs' externality". This point of view thinks that the diversification of the industry is more conducive to knowledge spillovers and diffusion and more innovation from different industries. Domestic and foreign scholars have explored the economic effects of these two kinds of externalities from various angles, and different views were obtained. Some scholars believe that the MAR externality is conducive to economic growth. Bishop and Gripaios[5], Mameli et al.[6] investigated the industry specialization and diversification on employment in the UK and Italy and they think that the agglomeration effect of specialized industrial structure is conducive to increasing employment and promoting economic growth. Jiang Yuanyuan[7] based on provincial data in 1990-2007, using the area weighted location quotient index and deviation share analysis method measured the contribution specialization sectors in the China northeast, central and western regions, the eastern four to economic growth and the conclusion is that industry specialization affects obviously on economic growth. Zhang Qizai[8] based on provincial data in 2002-2007, using a simultaneous equation model analysis, thinks that the regional specialization is the main path of promoting regional economic growth.

More scholars have found that Jacobs' externality has a role in promoting economic growth. On the one hand, the industrial diversification helps to expand the size of the market, enhance the ability of absorbing labor, and thus promote economic growth by increasing employment [9-12]. On the other hand, the industrial diversification has accelerated technological spillover between industries by the promotion of technological innovation to boost economic growth [13-17]. Further studies show that Jacobs' externalities are conducive to economic growth, but only when the technology of each industry has a complementary element or is correlated to each other. The diversification of industrial structure can boost economic growth by promoting employment or innovating technology [18-20].

Some other conclusions are also obtained about the relationship between the two externalities and economic growth. For example, the specialization and diversification are conducive to economic development based on rational combination [21], or the two impacts on economic growth are not significant [22]. The influence of two kinds of externalities is different on economic growth from the regional industrial scale [23] or different types of industries [24]. There is a nonlinear U-shaped relationship between the two externalities and economic growth [25-26].

Although the research on the relationship between industrial structure and economic growth has made some achievements, it is necessary to further explore the structural problems in the development of high-tech industry. Many studies have taken the high-tech manufacturing industry as a sample in the process of

examining the externality of high-tech industrial structure, the industrial scale factors are considered. This article takes the Herfindahl index, Shannon Dahl, Hector Seaman - Wiener index and K-L divergence to measure Chinese high-tech industry structure diversification and specialization, based on the panel data of 2003-2013 provincial high-tech industry Chinese manufacturing industry and high-tech industry in the service industry. It analyzes the relationship of linear and nonlinear between it and economic growth, specially the effects of the structure of high technology manufacturing industry and high-tech industry service industry. Also, the affect the scale structure of high technology enterprises has on economic growth.

THEORETICAL ANALYSIS

The structural theory of economic growth indicates that the change of industrial structure is the essential requirement to economic growth and is the internal power of the developing countries to realize long-term economic growth [27]. Practice has proved that the pattern of economic growth in developing countries must be transformed from the input expansion of unsustainable factors to the increase of productivity, and if the production factors play a role, they must rely on a certain industrial structure. The industrial structure influences the allocation of resource factors and productive efficiency. By adjusting the industrial structure, the factors of production continuously transform from lower productivity to the higher sector, which brings a "structural bonus" and promotes economic growth. Therefore, the adjustment of industrial structure is not only the inner demand of economic growth, but also an important driving force to economic growth.

According to Cobb-Douglas production function, economic growth is affected by inputting of the factors K, L and technical coefficient A. Essentially, the specialization of industry structure produced by the "MAR externality" and diversified industrial structure produced by the "Jacobs Externality" can improve the productivity or influence factor input through different ways further affecting economic growth.

FIGURE 1
SHOWS THE IMPACT SYSTEM OF THE TWO EXTERNALITIES OF THE INDUSTRIAL STRUCTURE.

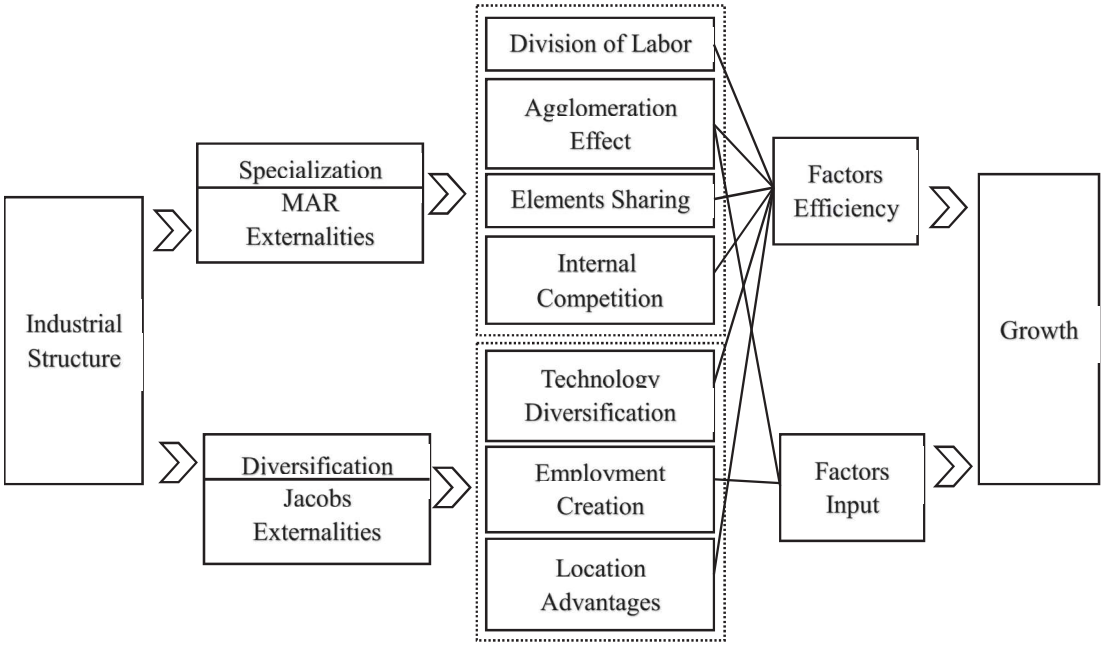

Figure 1: The influence mechanism of specialization and diversification of industrial structure on growth

If the"MAR externality" happens in the same industry, there is a higher degree of specialization and is more conducive to the emergence of externalities and economic growth. First, the theory of division of labor points out that it helps form skilled technology and improve production efficiency. The limited resources are put into specialized production, which can maximize their function. Second, the specialization of industrial structure can help the enterprises in the same industry to form geographical agglomeration and produce a agglomeration effect. Agglomeration is conducive to knowledge diffusion and technology spillovers within the industry, but is also conducive to increasing employment [5-6]. Third, the specialization of the industrial structure can make similar enterprises share the factors market, reduce the transaction cost of the factors flowing and improve the efficiency of the use of factors. Finally, the specialization of industry structure can strengthen the competition inside industry, yet the competition can promote the technical progress and productivity.

If the"Jacobs' externality" occurred in different industries, there will be a higher degree of industrial diversification and would be more conducive to the externalities of production. First, diversified industrial structure can shorten the distance of the knowledge and information flowing in different industries, so that the technology spillover happens among the enterprises in different industries. Different types of innovation agglomeration increases the possibility of new technology, so that it improves the productivity and promotes economic growth. Second, diversified industrial structure can create more employment, better quality of employment and reduced labor turnover. Finally, industrial diversification helps to perfect the industrial chain, form the location advantages, reduce the cost of enterprise innovation and improve productivity [17].

RESEARCH DESIGN

Industry Classification and Data Source Description

At present, research on high technology industries is only in the high tech manufacturing industry. This paper attempts to research high tech manufacturing and service industry simultaneously.

The Classification of the High-Tech Manufacturing Industry

According to the classification method from "the Classification of High Technology Manufacturing industry (Manufacturing) (2013)" issued by the National Bureau of Statistics, high technology manufacturing industry has been divided into five kinds, such as "pharmaceutical manufacturing, aviation, aerospace and equipment manufacturing, electronic and communications equipment manufacturing", "computer and office equipment manufacturing" and "medical equipment and instrument manufacturing industry" (the data sources from: the "Statistical Yearbook" of Chinese high technology industry).

The Classification of High-Tech Service Industry

Based on the classification from "the Classification High Technology Industry (Service Industry) (2013)" issued by the National Bureau of Statistics, and considering the provincial data availability, the selection of "information transmission, software and information technology services", "scientific research and technical services" as representative (the data source from" China Statistical Yearbook ") (High-tech manufacturing industry statistics are available from the "China Statistical Yearbook on High Technology Industry". However, "China Statistical Yearbook on High Technology Industry" is based on "high-tech industries (manufacturing) classification (2013)", it only contains the manufacturing data and currently there is no specific official statistical yearbook for the high-tech service industry. "China statistical Yearbook" was chosen as the data sources for high-tech service sectors. All other variables are derived from statistical yearbook of China.)

Variable Selection and Data Processing

The Explained variable

The gross regional product (Referred as GRP) is used as the explained variable, which can directly reflect the regional economic development.

Main Explanatory Variables

Three kinds of indexes were selected such as the " Herfindahl-Hirschman Index (referred to as the HHI)", the " Shannon-Wiener Index (referred to as SI) " and the " Kullback-Leibler Divergence (referred to as KLD)" to measure the diversity and specialization of the internal structure of high technology industry. The introduction of the square *"HHI²"and SI²"*is to inspect the possible nonlinear relationship between the diversification, specialization of high technology industry internal structure and economic growth. In order to explore the diversification and specialization of the high-tech industrial structure from many angles, this paper will take three variables as explanatory variables, as follows "the number of employees of high technology industry / the total employees in region (H/T),” "the number of employees of high-tech service industry / the total employees of the high technology industry (S/T)" and "the number of large and medium-sized high-tech enterprises / the total number of high-tech enterprises (L/T) ".

Control Variables

In addition to the above main explanatory variables, there are some higher degree factors affecting economic growth which need to be introduced as a control variable for regression analysis. First, the traditional Cobb-Douglas production function shows that capital, labor and technology factors have direct effect on economic growth and therefore three control variables have been introduced, " capital (K)", "labor (L)" and the technology innovation of "the patent application number (P)". Second, the agglomeration effect of economic factors conducive to economic growth [28], and thus the "population density (PD)" is a proxy for characterization of agglomeration. Third, the economic reformation has an important influence on economic growth. This paper mainly reflects the economic system reformation effect from two aspects: "the degree of openness" and "the degree of marketization". Openness degree is indicated by the foreign direct investment (FDI) accounted for GRP (F/G), yet the degree of marketization is shown by the non state-owned fixed asset investment proportion (N/T). Specific variables are shown in TABLE 1.

TABLE 1
DEPENDENT VARIABLE、MAIN INDEPENDENT VARIABLES AND CONTROL VARIABLES

	Name	Symbol	Description
Dependent variable	Gross Regional Product	*GRP*	
Main independent variables	Herfindahl-Hirschman Index	*HHI*	The formula is $HHI = \sum_{j=1}^{m}(s_{ij})^2$, in which $s_{ij} = x_{ij}/\sum_{j=1}^{m} x_{ij}$. x_{ij}, denotes the employment of industry j of province i and m is the number of high-tech industries. The maximum of *HHI* is 1 and the minimum is 1/m (it is 1/7 in this paper, around 0.143). The closer *HHI* and 1 are, the higher degree of high-tech industry's specialization of province i.

	Shannon-Wiener Index	*SI*	The formula is $SI = -\sum_{j=1}^{m} S_{ij} * lnS_{ij}$. The maximum of *SI* is ln (m) (it is ln7 in this paper, around 1.946). The closer *SI* and ln (m) are, there are more high-tech sub-industries in province i, namely higher degree of diversification, and meanwhile the more averagely employers being spread. Comparing with *HHI*, *SI* is less susceptible to the leading industry and it can more accurately reflect the diversification of regional high-tech industries.
	Kullback-Leibler Divergence	*KLD*	The formula is $KLD = \sum_{j=1}^{m} S_{ij} * \ln(S_{ij}/q_j)$, in which q_j denotes the ratio of industry j in high-tech industry national-wide. *KLD* is used to measure the relative difference of high-tech industry's structure between province i and the country. The higher *KLD* is, the more different they are. The minimum of *KLD* is 0, which denotes that they are totally the same.
	Square of *HHI*	HHI^2	To examine the non-liner relationship between high-tech industry's structure and growth.
	Square of *SI*	SI^2	
	Employment of high-tech industry/Total employment	*H/T*	To examine the impact of high-tech industry's employment on the growth.
	Employment of high-tech service industry/ Employment of high-tech industry	*S/T*	To examine the impact of the ratio of high-tech manufacturing and high-tech services on the growth.
	Large and medium-size enterprises/Total number of high-tech enterprises	*L/T*	To examine the impact of high-tech enterprises' scale structure on the growth.
Control Variables	Capital	*K*	Denoted by *Total investment in fixed assets*
	Labor	*L*	Denoted by *Total regional employment*
	Patents	*P*	Represents technological innovation
	Density of population	*PD*	The ratio of total number of population and area of the region, to denote elements convergence。
	FDI/GRP	*F/G*	To investigate the impact of opening effect caused by economical regime reforming.
	Ratio of investment of non-state-owned fixed assets	*N/T*	To investigate the impact of marketization effect caused by economical regime reforming.

Note: The source of areas of provinces is http://www.gov.cn/guoqing/gq_ztdf.htm.

Data Processing

(1) Fixed base processing. In order to eliminate the influence of price factors, with the year of 2003 as the base year, the GRP and the fixed asset investment data are treated by the consumer price index and the price index of investment in fixed assets. (2) Smoothing processing. The variables of GRP, K, L, P, PD are smoothed processing with the natural logarithm of the data. (3) To select the explanatory variable lag phase data in order to reduce the influence of the endogenous problem, the main explanatory variables and control variables used in this study are the data of lag phase.

EMPIRICAL RESULTS AND ANALYSIS

The regression results are shown in Table 2 and each explanatory variable is successively introduced into the model, so that the movement is from model (1) to the model (8). Based on panel data, there are mainly three regression methods of the fixed effect model, the random effect model and the mixed model. At first, according to the F test, the need to select the mixed effect model or the fixed effect model. Then, according to Hausman test, it was needed to determine the choice of the random effect model and fixed effect model. After the F test, model (1) to model (8) refused the original hypothesis of mixed effect model at 1% significant level. After the Hausman test, model (1) to model (7) refused the original hypothesis of the random effect model at 1% significant level. Using fixed effect model, model (8) failed to reject the original hypothesis, using a random effects model.

TABLE 2
THE EFFECT OF GROWTH ON THE INTERNAL STRUCTURE OF HIGH-TECH INDUSTRY

Explanatory variable	Model（1）	Model（2）	Model（3）	Model（4）
Ln（K）	0.560***	0.566***	0.566***	0.566***
	（37.71）	（37.66）	（37.70）	（37.74）
Ln（L）	0.171***	0.172***	0.191***	0.192***
	（3.82）	（3.88）	（4.17）	（4.19）
Ln（P）	0.036**	0.034**	0.035**	0.034**
	（2.28）	（2.14）	（2.19）	（2.15）
Ln（PD）	0.863***	0.818***	0.840***	0.829***
	（8.12）	（7.59）	（7.75）	（7.63）
F/G	0.021	0.022*	0.019	0.019
	（1.60）	（1.70）	（1.43）	（1.50）
N/T	0.328***	0.323***	0.338***	0.343***
	（3.19）	（3.15）	（3.30）	（3.35）
H/T	0.460*	0.645**	0.585**	0.741**
	（1.78）	（2.38）	（2.14）	（2.46）
S/T		0.170**	0.131	0.191**
		（2.12）	（1.56）	（1.97）

L/T			-0.140 （-1.58）	-0.140 （-1.58）
HHI				-0.254 （-1.23）
HHI^2				
SI				
SI^2				
KLD				
Section number	31	31	31	31
Total sample number	341	341	341	341
R^2	0.981	0.982	0.982	0.982
F test p value	0.000	0.000	0.000	0.000
Hausman test p value	0.000	0.000	0.000	0.000
Selection of regression method	FE	FE	FE	FE

TABLE 2（Continued）

THE EFFECT OF GROWTH ON THE INTERNAL STRUCTURE OF HIGH TECH INDUSTRY

Explanatory variable	Model（5）	Model（6）	Model（7）	Model（8）
Ln（K）	0.562***	0.566***	0.563***	0.556***
	（37.34）	（37.66）	（37.42）	（37.51）
Ln（L）	0.184***	0.190***	0.184***	0.437***
	（4.01）	（4.13）	（4.01）	（14.28）
Ln（P）	0.036**	0.035**	0.034**	0.024
	（2.24）	（2.18）	（2.17）	（1.62）
Ln（PD）	0.837***	0.838***	0.841***	0.097***
	（7.72）	（7.72）	（7.76）	（5.21）
F/G	0.019	0.019	0.018	0.013
	（1.47）	（1.47）	（1.39）	（0.99）
N/T	0.367***	0.343***	0.361***	0.087
	（3.56）	（3.33）	（3.49）	（0.89）
H/T	0.747**	0.658**	0.656**	1.074***

	（2.49）	（2.21）	（2.20）	（4.71）
S/T	0.213**	0.165*	0.171*	-0.130
	（2.18）	（1.65）	（1.71）	（-1.56）
L/T	-0.143	-0.143	-0.131	-0.109
	（-1.62）	（-1.61）	（-1.47）	（-1.37）
HHI	-1.309**			
	（-1.97）			
HHI^2	1.552*			
	（1.67）			
SI		0.050	-0.541	
		（0.62）	（-1.28）	
SI^2			0.209	
			（1.43）	
KLD				0.369***
				（7.31）
Section number	31	31	31	31
Total sample number	341	341	341	341
R^2	0.982	0.982	0.982	0.982
F test p value	0.000	0.000	0.000	0.000
Hausman test p value	0.000	0.000	0.000	0.998
Selection of regression method	FE	FE	FE	RE

Note: (1) *, * * and * * * were significant at 10%, 5% and 1% respectively. (2) The results of the regression indicate the number of variables t test values in brackets. (3) The measurement software used is stata12.0.

The coefficient of each control variable in each model is positive, which shows that it has an effect on promoting economic growth. This is consistent with the theory. The coefficients of three variables as capital (K), labor (L) and population density (PD) in all models are significant at 1% level. The coefficient of patent application number (P) in the model (1) to model (7) is significant at 5% level. The coefficient of the proportion of foreign direct investment accounted for GDP (F /G) in the model (2) is significant at the level of 10%. The coefficient of the proportion of non state-owned fixed assets investment (N/T) in the model (1) to model (7) is significant at 1% level.

The development of high-tech industry has significantly promoted economic growth, especially the high-tech service industry has shown its importance, but the large and medium-sized high-tech enterprises is not conducive to economic growth. The coefficient of H/T in different models is positive, and is

significant at different levels, which shows the high-tech industry with a strong economic power. The coefficient of S/T is positive in different models, and in the model (2), model (4) and model (5) is obvious at the 5% level, in the model (6) and model (7) is significant at the 10% level, it shows it would produce the economic growth effect if we increase the proportion of high technology service industry as a percent of high-tech industry. High technology service industry with high added value is the high-end part of the modern service industry. It is significant to cultivate high technology service industry for promoting the transformation and upgrading of industrial structure and economic growth. The coefficient of L/T in the model (1) to model (8) is negative and it shows that the large and medium sized high-tech enterprises, to a certain extent, are not conducive to economic growth. In fact, the small and medium-sized enterprises have high flexibility and autonomy in the process of technological innovation which is conducive to the creation of a higher efficiency. According to a survey by the association of small businesses in the UK, in small and medium-sized scientific and technological enterprises, the results of the per capita innovation is 2.5 times higher than that of the big enterprise. High-tech industry should pay more attention to the development of small and medium-sized enterprises.

The diversification and specialization of high-tech industries have no significant linear effect on economic growth, but there is a significant nonlinear relationship between HHI and economic growth. The coefficient of HHI in model (4) is negative, and the coefficient of SI in model (6) is positive, but the two are not significant. This means, diversification and specialization of the internal structure of the high technology industry have no significant linear effect on economic growth, only to a certain extent, the internal structure of high technology industry supports the assumption of Jacobs externality and refuses the assumption of MAR externality. In order to further investigate the possible nonlinear relationship between HHI, SI and economic growth, HHI^2 and SI^2 was respectively introduced to the model (5) and model (7). The results showed that the HHI coefficient of the model (5) is negative and significant at the 5% level. The coefficient of HHI^2 is positive and significant at the 10% level. The coefficient of SI in the model (7) is negative, the coefficient of SI^2 is positive and is not significant, which shows that there is a positive U significant non-linear relationship between HHI and economic growth, but it does not exist between SI and economic growth. This means that strengthening the specialization of industrial structure is conducive to economic growth when the HHI is greater than the critical value 0.422 ([1] According to $\mathrm{d}Y/\mathrm{d}HHI = 0$, namely $d(1.552HHI^2 - 1.309HHI)/dHHI = 0$, we can get"$HHI$*).increasing the diversification of industrial structure is conducive to economic growth when it is less than the critical value. From the table 2, it shows that the mean value of national HHI is 0.291 and lower than the critical value. So for the whole nation, the diversification of the high-tech industry should be improved.

In addition, model (8) also introduces KLD as the explanatory variable and its coefficient is positive, and it is significant at the level of 1%. This shows that when the more the difference of the high technology industry between each province and the country's is, the more significant to promote economic growth. In other words, the provinces' high-tech industrial structure should avoid the convergence with the national high-tech industrial structure and be based on their comparative advantages, build the optimal high-tech industrial structure, cultivate and develop the leading industries of the province.

CONCLUSION

This paper has discussed the relationship between diversification, specialization of high-tech industry and economic growth, based on the panel data of Chinese provincial high-tech manufacturing industry and high-tech service industry from the year 2003 to 2013, the basic conclusions are as follows: (1) There is a significant positive U-shaped non-linear relationship between structural specialization and economic growth in China's high technology industry. (2) The greater the difference between the provinces and the national high-tech industrial structure, the more significant it is to promote economic growth. (3) There is a significant growing effect to increase the proportion of high technology service industry within the high technology industry. (4) The large and medium-sized high-tech enterprises are not conducive to economic growth.

The implications of the paper are as follows: first, it should improve the degree of diversification of high-tech industrial structure for the whole country. Second, each province should try to avoid the convergence of high-tech industrial structure with the whole country. In the process of the development of high-tech industry, each province should not follow the national high technology industrial structure and should find the optimal high-tech industrial structure, based on comparative advantages of resources. Third, it should encourage the development of high-tech service industry. The high-tech service industry is an important driving force for economic growth, as a new service format based on high technology and support innovation of technology. It should increase the proportion of high-tech service industry accounted for high-tech industries, and give policy supporting of taxation, finance, human resource and so on, which should be the future direction of development of high technology industries. Fourth, it should encourage the development of small and medium-sized high-tech enterprises. The small and medium-sized high-tech enterprises are the most active innovation groups. It is of great significance to make a series of supporting policies of small and medium-sized high-tech enterprises for expending the development of high-tech industry and promoting economic growth.

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