The Development of High-Tech Industry in China by Data Processing

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Abstract: The expanding high-tech industry in China is attracting the world's attention. Meanwhile, researchers are attempting to find out what are the factors affecting the development of high technology innovations in order to make the best investment and policy changes possible to boost technological development by data processing. At the beginning of this paper, we investigated how would manpower input, financial input and technological output affect progress being made in the high-tech industry was analyzed. The results indicate that all these factors are positively correlated with better performance in the high technology industry. To be specific, financial input is more significant than the other two factors, particularly intramural expenditure. In the second section of the paper, we attempted to answer whether being a special economic zone is related with more desirable outcome in terms of high-tech innovations. The outcome demonstrates that being a special economic zone has no significant impact on the high-tech industry.

Keywords: High-tech industry, development, influencing factor, data processing

1 Introduction

Consistent advancement of high technology is both economically and scientifically crucial. Compared with traditional industrial sectors, high-tech industries are characterized by low raw material consumption, low energy consumption, high added value, high input, high risk and high permeability (Li, 2002) [1]. Unlike other developed economies, China does not own a head start in terms of developing advanced technology since the high-tech industry in China, in real sense, only started after the reform and opening in 1978.

High-tech industry has always been a central part of government's development plan in China since 1978: In August 1988, *the Torch Plan*, which was also known as *the National High Technology Industrialization Development Plan*, was implemented. To comply with *the Torch plan*, most of the provinces started setting up High-tech Industrial Development Zones based on their own economic and environmental condition. In 1993, *the revised Law on Science and Technology* came into effect, and detailed regulations that support the implementation of the policies from the Torch plan were successively promulgated, which mainly includes tax incentives and R&D investments from the government. To summarize the different stages of development for high-tech industry in China, breakthroughs have not only been achieved in terms of the construction of High-tech Industrial Development Zone to set up examples for other

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regions, but also in respect to policies innovations such as equity-based incentive, fiscal support and tax preference to provide high technology enterprises with an incentive to innovate and make technological progress. Although those policies were only implemented inside the zones when they were first launched, they were soon adapted by surrounding regions and prevailed across adjacent provinces. Most notably, several industrial clusters with high market share and strong competitiveness have been developing and expanding, and a relatively reasonable layout of high-tech industrial system has initially taken shape.

The high-tech industry plays a crucial role in national economies. The indicators for high-technological advancement in China increase steadily and high-tech industry contributes to a large part of economic growth and development in modern China: up until 2020, the number of employments created by the high-tech industry is more than 4.5 million. Government funding for R&D (research and development) expenditure increased by 10.3% compared with that of 2019, accounting for 2.4% of GDP. In 2020, high-tech industries accounted for 5.3692 trillion yuan of total imports and exports of goods, an increase of 6.5 percent over the previous year (Statistics Bureau of the People's Republic of China,2021) [2].

Manpower input and various expenses are generally considered as important factors affecting the development of high-tech industries in different cities. In addition, we assume that the establishment of special economic zones also boost the development of high-tech industries to a certain extent. Special economic zones, which is also known as one of the main forms of freeport zones, are regions that carry special economic policy and economic system. With the intention to introduce advanced technological and scientific management methods and to promote economic and technological development of the country where the zones are designated, special economic zones adapt preferential policies such as tariff reduction and exemption that encourage foreign investment and technical progress. There are currently seven special economic zones in China. Taking Hainan as an example, according to figure 1, after the establishment of the special economic zone in 2010, many foreign investments were introduced, and the annual growth rate of the total profit of the high-tech industry rosed significantly from 6.6% in 2012 to 29% in 2016. [3]

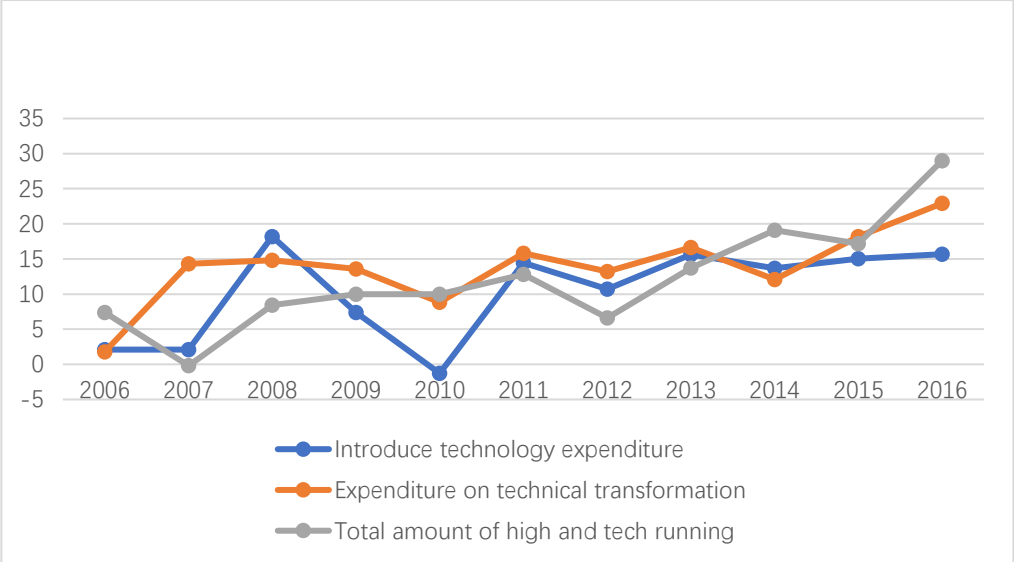

Figure 1: Percentage increase in total sales revenue of new products, expenditure on technical renovation and import from 2006-2016, Hainan

For this research paper, we are intended to explore further into the influencing factors on the development of high-tech industry in China: what are the most significant factors boosting growth? Are increasing technological output more effective than investing in human resources and technology? Does being a special economic zone correlate with better performance in the technological industry? In order to answer those questions, we collected data from 2001 to 2019 of six cities, including three cities in the special economic zone and three cities that are not. We then carried out a regression, and based on the results, analyzed and explained the mechanism behind each outcome.

The paper is mainly divided into four sections. In the first section, we addressed the importance of this research topic, presented several observations and assumptions and summarized relevant published papers and theories. In the second section, we chose six factors based on our statistical analysis and investigated to which extent each percentage increase in these factors would make a difference to the high-tech industry. The third section is the first attempt to investigate whether there is a correlation between being a special economic zone and better performance in the high-tech industry. The last section, we concluded the results we attained through our theoretical research and statistical analysis and made several suggestions to both investors and policy makers.

2 Literature review

The development of high-tech industry and its influencing factors have always been popular topic among scholars. In 1971, the National Academy of Sciences of the United States first put forward the concept of high technology in *Technology and National Trade*. In terms of the definition of high-tech industry, the department of commerce of the United States draws on its

research to define the high-tech industry based on two aspects: one is the professional and technical personnel engaged in the industry, the other is the proportion of R&D in sales. In previous publications, the researchers discussed various factors that influence the development of high-tech industry such as price, geographical factors, and patents. To be specific, Jooh Lee (1995) selected data of the high-tech industry from the United States and Japan and concluded that the long-term performance and market share of enterprises would increase with the increase of R&D funds, thus stimulating technological progress and promoting growth.[4] Triplett (1995) took the relationship between characteristic price index and technical efficiency as a starting point, and his results indicated several indexes affect the technical efficiency of high-tech industries.

Domestic research on high-tech industry started relatively late. On May 6, 1995, *"The Decision of the CPC Central Committee and The State Council on Accelerating Scientific and Technological Progress"* clearly pointed out that "the national industrial policy and development plan should prioritize the development of technological industry. This was a milestone towards the great march of exploring the influencing factors on high-tech development. Since then, numerous research papers related to the growth of high technology industry in China emerged. To be specific, Liwei Cheng（2010), the Malmquist index productivity model based on DEA is used to measure industrial efficiencies, and it is found that due to the pursuit of rapid development, the quality of growth has been neglected in most regions in China by developers and enterprisers. Also, the results demonstrated the fact that the quality of the FDI (foreign direct investment) in the high-tech industry did not reach the standard for efficient development and expected growth. This result, on the other hand, also supported the outcome of our regression analysis that high-tech industrial development is negatively correlated with the establishment of special economic zones that accept excess amount of FDI.

In this paper, we made the first attempt to make a statistical analysis in order to investigate whether there is a correlation between being a special economic zone and performance in the high-tech industry.

Considering all the past research, our paper is based on the following assumptions:

Assumption 1: economic growth, enterprise scale, enterprise system, policy factors, market factors and institutional factors such as national science and technology management system, property rights system and incentive system are all exogenous variables of the growth of China's high-tech industry. This paper examines the factors influencing the growth of high-tech industry from 2001 to 2019, except for 2017 since the yearbook was not published in 2018. Since these factors are constantly changing during this period and are impossible to quantify, we assume that these exogenous variables do not affect the test results.

Assumption 2. There is an increasing return to investments in human resources, R&D and policies that fuel the growth of the high-tech industry. As a result, both theoretical research and the development process of developed countries have proved that the growth of high-tech industry is nonlinear. Therefore, our regression analysis

3 Methodology and data

a) human resources, investments and technological output as influencing factors

Correlation analysis on the factors affecting the development of high-tech industry

The selection of independent variables should not only consider their comprehensiveness and representativeness, but also ensure their relative independence. Based on this premise, this paper selects the factors affecting the development of high-tech industries and the evaluation index of the dependent variable while taking the characteristics of high-tech industries in China into consideration.

There are two types of investments that support the high-tech industry: human investment that and financial investment. The overall innovative efficiency of the country is highly correlated with the quantity and quality of human and financial investment into various industries. Specifically, manpower input in the high-tech industry is mainly evaluated through professionals who are engaged in technological innovation activities. Financial investment in high-tech industries is mainly capital investment, including expenditure on technical renovation, expenditure on technology import, intramural expenditure, extramural expenditure and expenditure on technology absorption, etc. In terms of technological innovation output, we collected data for sales revenue from new products from six provinces. Since new products are the commercialization of technological innovations, we can evaluate the extend of which technology innovations have been transformed into market values in the high-tech industry.

Based on analysis above, the first section of statistical analysis focuses on six independent variables: the average number of employees as X1, intramural expenditure as X2, sales revenue from new products as X3, expenditure on technology import as X4, expenditure on technology absorption as X5, and expenditure on technical renovation as X6. Among all six factors, X1 indicates manpower input, X3 demonstrates technological output, and the rest of the factors are categorized as financial inputs and investment.

In this section, correlation matrix, KMO and Bartlett test was conducted using SPSS to examine and demonstrate the correlation between the factors above and the development of high-tech industry. The data in this paper could be found in the *China Statistics Yearbook on High Technology Industry,* 2002-2020.

Table 1: Correlation matrix for the six variables

Correlation matrix							
Correlati		X1	X2	X3	X4	X5	X6
on	X1	1.000	.529	.346	.560	.602	.464
	X2	.529	1.000	.145	.200	.712	.597
	X3	.246	.645	1.000	.375	.567	.613
	X4	.730	.200	.275	1.000	.750	.684
	X5	.302	.112	.267	.550	1.000	.306
	X6	.364	.597	.413	.084	.206	1.000

As Table 1 shows, Correlation matrix is a table consists of rows and columns, and each cell in the matrix includes a correlation coefficient that indicates how close one independent variable is related to another in a multiple linear regression. Through SPSS software, data was inputted for factor analysis, and the resulted correlation coefficient matrix is shown in Table 1. Through interpretating and analyzing the results, it is concluded that the data is suitable for factor analysis.

Table 2: KMO and Bartlett's Test for the six variables

BMO Measure of Sampling Adequacy	.732	
Bartlett's Test Sphericity	Approx Chi-Square	87.727
	df	21
	Sig.	.000

As Table 2 shows, A KMO and Bartlett's Test is also conducted, and the results obtained are shown in table 2. The two tests indicate the suitability of the data for multiple linear regression. The In terms of the KMO test for the independent variables, the KMO value of the sample is 0.732, which falls into the range of 0.7 to 0.8, and this indicates that the independent variables are generally adequate and suitable for factor analysis. As for the Bartlett's test, the critical value of the chi square is 87.727, and the significance probability (s) is 0.000 under degree of freedom (df) of 21. It proves certain correlation between the variables, which indicates that the statistical data is suitable for factor analysis.

b) Regression analysis

Through the Excel spreadsheet, data from 2002 to 2012 collected from six different provinces were inputted for multiple linear regression analysis, and the test results were shown followed:

Table 3: Regression Statistics

Regression Statistics	
Multiple R	0.95480826
R Square	0.91165882
Adjusted R Square	0.90641083
Standard Error	0.62422516
Observations	108

Table 4 ANOVA ANOVA

	df	SS	MS	F	Significance F
Regression	6	406.1374722	67.6895787	173.715778	6.81517E-51
Residual	101	39.35536262	0.38965706		
Total	107	445.4928348			

Table 5 Results from regression analysis between the six factors and sales revenue from new products

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-5.3969716	0.545242438	-9.898297	1.5034E-16	-6.47858589	-4.31535724	-6.47858589	-4.3153572
X1The average number of employee	0.11979012	0.116688427	1.02658095	0.30707018	-0.11168833	0.351268566	-0.11168833	0.35126857

X2International expenditure	0.71998939	0.094735827	7.5999695	1.5561E-11	0.532058997	0.907919791	0.532058997	0.90791979
X3Sales revenue from new products	0.02680027	0.086430325	0.31007946	0.07571394	-0.14465425	0.198254784	-0.14465425	0.19825478
X4Expenditure on technology import	0.01560458	0.060172136	0.22609429	0.00321593	-0.13296991	0.105760755	-0.13296991	0.10576076
X5Expendoture on technology absorption	0.18120357	0.050333383	3.60006733	0.00049504	0.081355676	0.281051462	0.081355676	0.28105146
X6Expenditure on technical renovation	0.17482236	0.053470122	3.26953355	0.00147357	-0.28089269	-0.06875202	-0.28089269	

The regression equation obtained from the table 3, table 4 and table 5 is:

Y=0.1198x1+0.7200x2***+0.0268x3*+0.1560x4*+0.1812x5***+0.1748x6***-5.3970

Note: *** means passing the 1% significance test, * means passing the 10% significance test

It can be seen from the test results that R square is 0.91165882 which its value is close to 1. Therefore, the forecast results are quite consistent with the actual situation. Therefore, the data in this table can be used to analyze the influence of different factors on the development of high-tech industry.

In terms of P-value, the most significant is the internal expenditure of R&D funds, which passes the 1% significance test; The second is expenditure on absorption, which passes the 1% significance test; The third is expenditure on technical renovation passing 1% significance test. X4 passed the significance test of 5%. What is not significant is the average number of employees and the sales revenue of new products, which did not pass the significance test and was greater than 10%.

All factors form positive correlation with the dependent variable. The coefficients of each factor obtained in the regression equation are 0.120, 0.720, 0.027, 0.156, 0.181 and 0.175, respectively. From this perspective, we can see that: The coefficient of the internal expenditure of R&D funds is 0.720 which is significantly higher than the coefficient of sales revenue of new products which is 0.027. The coefficient of the average number of employees is 0.120. This indicates that the internal expenditure of funds has the strongest correlation among all the factors affecting the development of technological innovation in high-tech industry. The followings are the expenditure on absorption, the expenditure on technical renovation and the expenditure on technology import. Their coefficients are 0.181,0.174 and 0.156 respectively. Therefore, in order to the boost the development and promotion of the whole industry, it is necessary to increase the expenditure on absorption, the expenditure on technical renovation and the expenditure on technology import.

From the perspective of capital investment, the dependence of the development of high-tech industry on high-tech achievements is directly reflected by the increasing trend of R&D expenditure and R&D activity expenditure (Dan Shi, Li Xiaobin,2004) [5]. In high and new technology industry, the demand for scientific level is becoming higher and higher and the technology will be more dependent on the frontier science research breakthrough. In this case, the internal expenditure of R&D funds as the funds directly invested on the R&D activities, including technology research, development and experiment becomes the most important factor.

The expenditure on technical renovation applies scientific and technological achievements to various fields of production and replaces backward equipment in time; Expenditure on absorption is the application of imported technology and innovation based on this, and the role of expenditure on renovation is roughly the same -- both are to make technology to keep up with the time, so both are highly correlated with industrial development.

The introduction of foreign advanced technology can make use of foreign high and new technology to make up for the domestic technical shortcomings, especially in the case that China has lagged western countries due to the problems left over by history. Therefore, increasing funds for the expenditure on technology import can take advantage of other countries to promote industrial development. However, compared with the other two factors -- internal expenditure and absorption of funds, the introduction of technology is not so closely related to the industrial development. The reason may be that it is difficult to introduce core technology due to the fierce competition in the industry, so the effect of this part is not obvious.

On the other hand, among other factors affecting the development of high-tech industry, the sales revenue of new products as one of the important indicators reflecting the development of high-tech industry, is not so prominent. The reason for this may be that the high-tech industry is a knowledge - and technology-intensive industry, which has great difficulties in the volume and speed of development. However, from a positive point of view, if these existing difficulties can be solved, it will bring huge economic and social benefits and improve the efficiency of technological innovation in various industries. The average number of employees has no significant impact on the development of high-tech industry. The reason may be that in the era of technology wave, more and more people are flooding into high-tech industry to demand opportunities. However, compared with the annual increase in employment, the overall quality of personnel has not been greatly improved. Especially for high-tech industries, compared with traditional industries, the success or failure of high-tech industries and the development of enterprises depend on the availability of talents with outstanding innovation ability who master the development and management of high-tech resources. As for China, the growth of high-tech industries and the talent of high quality high and new technology industry growth rate does not match. (Bin Li, Ji Zhang, 2009) [3] of skilled talents, such as embedded software development division, radiation technology, new materials scientists such as obvious shortage of senior skilled workers, a strikingly low proportion and so on. As a result, the overall level of the technical quality of the labor force is low, and it cannot vigorously promote the development of high-tech industries.

Therefore, for the development and promotion of the whole industry, it is essential to strengthen the investment in research, development and experimental funds, increase the salary of researchers, actively introduce foreign advanced technology, and regularly update and transform production equipment to replace backward technology to improve the production quality and efficiency of high-tech industries

4 Special economic zone as influencing factor

Regression analysis

In this section, data is collected from six provinces: Hainan, Fujian, Guangdong (special

economic zone) and Sichuan, Gansu, Zhejiang (not special economic zone). Our statistics for this section are also generated form *the China Statistics Yearbook on High Technology Industry* from 2002 to 2020, except for 2018. This section ran a regression line to observe the impact of being a special economic zone on the development of high-tech industry. The independent variable investigated is whether the region belongs to a special economic zone, which is X7, and the dependent variable is the sales revenue from new products.

Table 6 Regression Statistics

Regression Statistics	
Multiple R	0.150418
R Square	0.022626
Adjusted R Square	0.013405
Standard Error	2.026739
Observations	108

Table 7 ANOVA ANOVA

	df	SS	MS	F	Significance F
Regression	1	10.07957	10.07957	2.45384	0.120218
Residual	106	435.4133	4.107672		
Total	107	445.4928			

Table 8: Results from the regression analysis between being an economic zone and sales revenue for selling new products

	coefficients	Standard Error	T Stat	P-value	Lower 95.0%	Upper 95.0%	Lower 95.0%	Upper 95.0%
Intercept	4.074751	0.275804	14.77407	1.72E-27	3.527942	4.62156	3.527942	4.62156
X7 Special Economic Zone	0.610997	0.390046	1.566474	0.120218	-0.16231	1.384302	-0.16231	1.384302

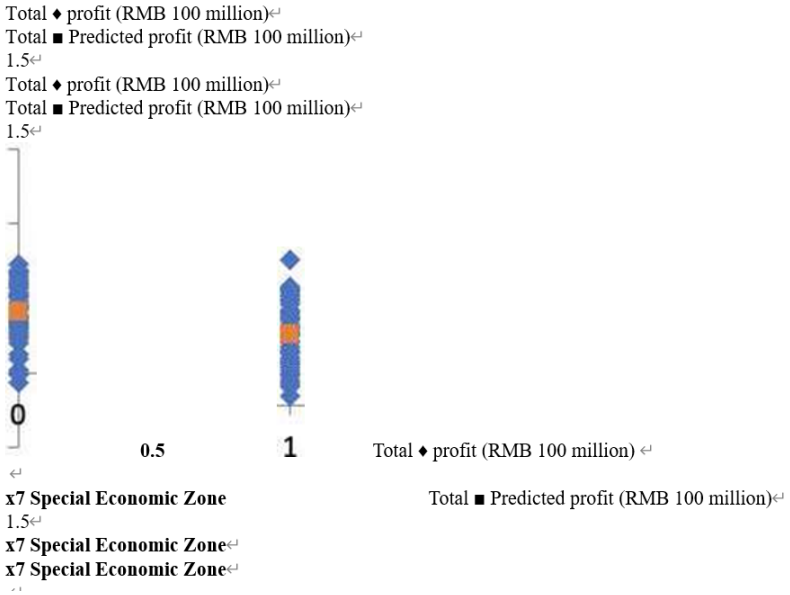

Figure 2: Line fit plot that represents the relationship between *being an economic zone* and *sales revenue for selling new products*

According to Table 6, Table 7, Table 8 and Figure 2 above, the R sqaure is 0.022626, which is far less than 1 and indicates that there is no linear correlation between being a economic zone and more outstanding performance in the high-tech industry.

Based on statistical analysis above, we would briefly analyze the mechanism that explains why preferential policies in special economic zones do not boost growth in the high-tech industry: Firstly, special economic zones have introduced a large amount of foreign investment that is not beneficial to high technology development. According to Jiang Dianchun, who used the panel data model to analyze the influence of FDI on the technological innovation ability of domestic high-tech technology industries, the competition effect of FDI is not conducive to the growth of the innovation ability of domestic enterprises and regions as a whole. [3] Secondly, some special economic zones failed to take the advantage of their geographical locations. Take Shantou, a special economic zone established in 1981 as an example: Shantou is located in Guangzhou, which is an economically advanced province in China with booming high-tech industry, and Guangzhou is also a city that we took into account when collecting data. The city is also not far from Shenzhen and Xiamen, which are both highly-developed region. The city of Shantou could have taken advantage of its geographical advantages to develop together with the surrounding economic centers. However, due to its indecisive development strategies and undesirable economic policies, its economic potential gradually depleted.

5 Conclusion

Based on the data from the *China Statistics Yearbook on High Technology industry,* this paper found that there is a positive correlation between manpower inputs, financial inputs,

technological output and development of the high-tech industry. However, it is also found that being an economic zone does not have significant benefits on regions' high technology innovative capabilities. Our statistical outcome also suggested that the quality of professionals and investments into the high-tech industry is plays a more important role than the quantity of inputs.

Based on analysis, it is believed that if a country with weak innovation ability wish to develop its high-tech industries, it should actively attract and introduce advanced technology from foreign countries and high-quality FDI to promote the development of its innovation capacity and formulate policies to assist the development of domestic firms. If the country has already developed a certain level of innovation ability, it should encourage the development of domestic high-tech firms.

Finally, the statistical analyze above give the following suggestions to countries that wish to develop its high-tech industry. Firstly, countries should actively exploit the advantages of geographical locations to attract high-quality FDI and achieve sustainable development. Secondly, countries should take the chance to grasp opportunities and make national policies according to their own economic and technological background. Thirdly, regional governments, especially the governments of special economic zones, are expected to pursuit high-quality sustainable growth rather than only focusing on the quantity.

Nonetheless, a few limitations still exist in this paper. Due to the lack of clarity of the data, we did not consider the impact of exogenous factors such as the introduction of high technology professionals and High Technology Development Zone. As for high-tech industries, China has various policies such as high-tech industrial and development zones to promote development, which may be the reason why the establishment of special economic zones are negatively correlated to the development of high-tech industries.

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