Study on the Economic Effects of Regional High Technology Industry Agglomeration——Taking the Pearl River Delta City Cluster as an Example

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Abstract. This paper summarises the mechanism of industrial agglomeration and analyses the characteristics of high-tech industrial agglomeration. On this basis, it analyses the economic effects of regional high-tech industrial agglomeration, including: reduction of enterprise operation and transaction costs, specialised division of labour, innovation effect, agglomeration of high-tech talents, "brand" effect. A system of indicators is constructed to measure the above five effects Based on the data from 2009 to 2019, factor analysis and regression analysis are used to analyze the multiple effects of high-tech industry clustering on regional economic growth in the Pearl River Delta region. The results show that the innovation effect and the concentration of high-tech talent have the most obvious effect on the economy of the PRD region, while the reduction of enterprise costs and the specialised division of labour are also important factors, but the role of the "brand" effect is not obvious.

Keywords: Regional Economy; High-tech Industrial Agglomeration; Pearl River Delta City Cluster; Factor Analysis

1 Introduction

With economic globalization and the rapid development of industrial technology, high-tech industries have become an important force for sustainable economic development by virtue of their intensive knowledge and technology elements, low resource consumption and high added value. At present, the total number of high-tech zones in China has reached 173. In 2021, the gross domestic product of the national high-tech zones was 15.3 trillion yuan, creating 13.4% of GDP from 2.5% of the national construction land, contributing to the development of science and technology innovation as "high-tech power". In recent years, the Pearl River Delta urban agglomeration has continued to promote industrial upgrading and transformation, with a clear trend of industrial upgrading. The proportion of high-tech manufacturing industry added value to industrial added value above designated size is an important indicator that reflects the urban industrial structure and innovation level. Shenzhen, known as the "Innovation City," achieved 67.4% of this indicator in 2020, while Dongguan, Huizhou, and Zhuhai achieved 39.53%, 43.8%, and 31.3% respectively. It is of practical significance to study the diversified effects of high-tech industry agglomeration on regional economy in the Pearl River Delta urban agglomeration.

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Industrial agglomeration is the high concentration of the same industry in a specific geographical area, and the enterprises in the agglomeration area directly or indirectly influence the regional economic growth through the improvement of production efficiency and the diffusion effect. High-tech industries refer to manufacturing industries with relatively high R&D input intensity in national economic sectors. Compared with other industries, the agglomeration of high-tech industries has the characteristics of highly intensive knowledge and technology, which can accelerate industrial structure upgrading, improve regional innovation capacity and competitiveness, and influence the economic development of neighbouring regions through the spillover of knowledge and technology. Hu and Gao (2020)[1] show that high-tech industrial agglomeration can effectively promote regional technology absorption and that human capital is the mediating path of high-tech industrial agglomeration on regional technology absorption. You (2018)[2] analyzed the factors affecting high-tech industrial agglomeration from three aspects: factors, institutional environment and industrial environment, and sorted out the effects of high-tech industrial agglomeration from several perspectives: technological innovation effect, spillover effect, economic growth effect and employment effect. In recent years, many scholars have empirically analyzed the economic driving effect of regional high-tech industry agglomeration, and most of them use location entropy to measure the degree of high-tech industry agglomeration. Wu et al. (2019)[3] calculated the location entropy of cities in Shandong Province with high-tech industry output value, and used it as the core explanatory variable to argue that the level of high-tech industry agglomeration specialization is the main driving force of regional economic high-quality development. Some scholars have also used the main business income of high-tech industries to calculate locational entropy (Ma et al., 2020)[4]. Guo and Huang (2021)[5] used the number of people employed in high-tech industries to calculate locational entropy, which was used to measure the degree of agglomeration of high-tech industries and to empirically test the impact of agglomeration of high-tech industries on the quality of economic growth and its heterogeneity among regions.

In the past, scholars have mostly used location entropy as the core explanatory variable to analyse the impact of high-tech industrial agglomeration on regional economic growth, but this approach cannot reflect the extent to which the multiple economic effects of high-tech industrial agglomeration promote regional economic growth respectively. Based on the theory of industrial agglomeration, this paper will analyze the characteristics of high-tech industrial agglomeration and its multiple economic effects, so as to more comprehensively reflect the impact of the multiple effects of high-tech industrial agglomeration on regional economy, and use the Pearl River Delta city cluster as an example for empirical analysis.

2 Characteristics of High Technology Industry Clusters

The study of industrial agglomeration originated in the late 19th century, and Marshall elaborated on the economic drivers of industrial agglomeration under the conditions of external economy and scale economies. He proposed three reasons for industrial agglomeration: firstly, agglomeration can promote the development of specialized investment and services; The second is that enterprises gather in a specific space to provide specific industrial skills in the labor market, thereby ensuring a low probability of unemployment for workers and reducing the possibility of labor shortages; Third, industrial agglomeration can

produce spillover effects, making the production function of clustered enterprises superior to the production function of individual enterprises, and the enterprise benefits from the spillover of technology and information. Weber's industrial location theory believes that the "location factors" composed of labor costs, transportation costs, and agglomeration economy promote the occurrence of industrial agglomeration. When the migration costs incurred by enterprises in pursuit of agglomeration benefits are less than the benefits or costs saved by enterprises due to industrial agglomeration after migration, industrial agglomeration naturally occurs. Krugman's New Economic Geography theory mainly studies how "the law of increasing returns to scale" affects the spatial agglomeration of industries. Krugman affirmed Marshall's early external economic thought, believing that economic activities tend to concentrate in geographical locations. On this basis, Krugman reinterpreted Marshall's viewpoint and summarized that there are three reasons for the phenomenon of industrial localization: basic elements, intermediate inputs, and the use of technology, all of which generate external economic factors from the supply side. Like traditional industrial agglomeration, the formation of high-tech industrial agglomeration is affected by transportation costs, factor acquisition costs, competitive products, economies of scale and other factors. As high-tech industries are a kind of industrial clusters that use modern cutting-edge technologies to produce high-tech products, high-tech industries have the characteristics of low consumption of raw materials, low energy consumption, high added value, high investment, high risk, high return, and high permeability (Shi and Li, 2004)[6], There are also two particularities in the formation mechanism of industrial agglomeration:

High innovation demand. High-tech enterprises need to constantly introduce fashionable and personalized products in the face of the fast changing consumer demand. The speed of innovation creates value. If an enterprise enters the market slowly, it is likely to face a shrinking low-profit market entering a period of recession (Wang and Zhao, 2001)[7]. Therefore, the resource conditions required for the agglomeration of high-tech industries not only include the supply of infrastructure and capital, but also sufficient human resources to meet the high innovation of high-tech industries. In traditional industries, general human capital accounts for the vast majority of enterprises. High tech industries are intelligence intensive enterprises, and innovative human capital is the source of innovation income. Regions with concentrated scientific research institutions, universities, or high levels of labor specialization will attract high-tech industry clusters, forming industrial zones with high levels of technology and innovation capabilities.

Higher spillover of knowledge is easier to spawn enterprises. The talent and knowledge possessed by the original enterprise are the prerequisite for the derivation of the enterprise. The prominent characteristics of high-tech industries are knowledge spillover and specialized talents, so high-tech industries are more likely to generate derivative enterprises and form high-tech industry clusters. After the initial scale of high-tech industry agglomeration, the knowledge spillover effect of high-tech industries will accelerate the specialization of division of labor and accelerate the speed of industry innovation. The geographical advantages brought by industrial agglomeration to high-tech industrial zones can also accelerate the convenience and speed of technology exchange and knowledge dissemination among enterprises within high-tech industries, further promoting the continuous expansion of high-tech industry agglomeration areas.

3 Multiple economic effects of high-tech industry agglomeration

Combined with the analysis in the previous section, high-tech industry has the significant characteristics of knowledge-intensive and faster knowledge spillover speed than traditional industries, so the scale effect and external effect generated by agglomeration are more significant. Compared with other industries, high-tech industry has significant effect of high innovation, high-tech talent agglomeration effect and "brand" effect. Therefore, this paper analyzes the economic effect of high-tech industry agglomeration from the following five aspects.

Similar to traditional industrial agglomeration, high-tech industrial agglomeration can reduce the operation and transaction costs of enterprises, improve the competitiveness of regional high-tech industries and increase profits. From the perspective of production cost, the high-tech industrial agglomeration area has all the links from upstream raw material supply to downstream production and distribution, and the distance between them is very close, which greatly reduces the transportation cost. After the formation of industrial clusters, many enterprises can share infrastructure, and the agglomeration effect of high-tech zones can attract a large number of various service organizations to distribute around them (Fang et al., 2011)[8]. In addition, auxiliary industries such as providing tools, services and raw materials can also reduce the unit cost of services within clusters, and the geographical proximity reduces the cost of information seeking for enterprises.

Specialized division of labor can improve the production efficiency of enterprises. The scale advantage of industrial agglomeration and technological innovation advantage will play an important role in promoting total factor productivity growth (Chen and Zhan, 2019)[9]. A large number of similar types of enterprises gather in the same area, which can form professional division of labor and cooperation. Enterprises in the agglomeration area have similar business types, many of them are in the same production chain, and there are upstream and downstream cooperative relations and frequent transactions between them. Enterprises in the agglomeration area can share information technology and exchange research and production experience. Personnel with different specialties and backgrounds can communicate extensively, which makes it easier to form a professional division of labor, thus improving production efficiency.

The innovation effect of high-tech industry agglomeration. The agglomeration of high-tech industries will enhance the scientific and technological innovation ability of the agglomeration region. The essence of innovation-driven development is the process of the transfer and diffusion of high-tech industry innovation to low and medium technology industries, which drives the improvement of total factor productivity and optimization of resource allocation of low and medium technology industries (Wang et al., 2015)[10]. The agglomeration of high-tech industries achieves innovation effects by collecting innovative resources in the early stage, promoting cooperation among enterprises, and building an innovation network within the entire agglomeration area. It can promote the gradual formation of a large number of high-level and high-quality cross research platforms and research institutions in the region, and bring innovation advantages and scale effects to high-tech industries. It also provides resource advantages for technological innovation in other industries in the region, Thus driving regional economic growth.

Agglomeration of high-tech talents. The gathering area provides a good technological innovation atmosphere for specialized talents, allowing them to gather in a unified area. Helping enterprises in the agglomeration area find suitable specialized talents at a lower cost, high-tech industry agglomeration accelerates the concentration of specialized talents, and high-tech talents in the agglomeration area quickly provide information feedback, which can quickly identify technical problems, generate new innovative ideas, and improve the level of specialization, continuously optimizing the regional industrial structure.

“Brand” effect. The high-tech industry requires a large amount of investment in product research and development, including early research and development, trial production, and later production, manufacturing, and market promotion. The "brand" effect of high-tech industry agglomeration allows external investors to fully understand the current situation and future development potential of high-tech enterprises, and also conveys reliable signals to investors. Therefore, enterprises in the agglomeration area are more likely to win investment from investors, enabling them to obtain financial support to develop new products or functions, maintain product differentiation, and expand production scale of enterprises in the agglomeration area, This investment environment can also benefit other industries. This article believes that this effect has a significant driving effect on the early stage of enterprise development, especially in driving the gradual development and strengthening of small and medium-sized enterprises, and promoting regional economic growth.

Based on the above analysis, indicators are selected to quantify the multiple effects of the high-tech industrial agglomeration, as shown in Table 1, so as to analyze their respective impacts on regional economic growth in the following empirical analysis.

Table 1 Indicators Corresponding to the Agglomeration Effect of High-tech Industries

The Economic Effects of High- tech Industry Agglomeration	Indicators
Reduce operational and transaction costs for enterprises	Total profit of regional high-tech industries/total profit of national high-tech industries (X_1)
Specialized division of labor	Main business income of regional high-tech industries/Main business income of national high-tech industries(X_2)
The innovation effect	Total R&D expenditure of high-tech industries in the region/total R&D expenditure of high-tech industries in the country(X_3)
Agglomeration of high-tech talents	Regional average of high-tech industry employees/national average of high-tech industry employees(X_4)
“Brand” effect	Number of high-tech enterprises in the region/Number of high-tech enterprises in the country(X_5)

4 Empirical analysis in the Pearl River Delta region

Refer to the sample data from 2009 to 2019 in the ***China High tech Industry Statistical Yearbook***, ***China Statistical Yearbook***, and ***Guangdong Statistical Yearbook*** based on the indicators constructed in Table 1. This article replaces the data from the PRD region with data from Guangdong Province (where the data from 2017 was missing, so it was deleted), conducts factor analysis, and constructs a regression model to analyze the multiple effects of high-tech industry agglomeration in the PRD region on promoting regional economic growth. Firstly, perform correlation tests on the five indicators, and the Pearson correlation coefficient matrix obtained is shown in Table 2.

Table 2 Correlation Matrix

	X_1	X_2	X_3	X_4	X_5
X_1	1	.732*	.185	.403	.372
X_2	.732*	1	.180	.464	.646*
X_3	.185	.180	1	.747*	-.428
X_4	.403	.464	.747*	1	-.332
X_5	.372	.646*	-.428	-.332	1

*. At the 0.05 level, the correlation was significant.

The results in Table 2 show that there is a strong correlation between several variables. In this paper, factor analysis is used to summarize them into a few common factors to facilitate regression analysis. Principal component analysis is used to extract common factors, and two common factors are extracted in total. The total variance explained table is shown in Table 3:

Table 3 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Totol	% of Variance	Cumulative %
1	2.397	47.941	47.941	2.397	47.941	47.941
2	1.955	39.110	87.051	1.955	39.110	87.051
3	.381	7.624	94.674			
4	.243	4.860	99.534			
5	.023	.466	100.000			

The sum of the variance contribution rates of the first two common factors is greater than 85%, indicating that these two common factors can better summarize these five indicators. Then, the maximum variance method is used to rotate the factors, striving to find common factors with clearer meanings. The rotated factor load matrix is shown in Table 4:

Table 4 Component Matrix

	Component	
	f_1	f_2
X_1	.835	.244
X_2	.955	.169
X_3	.025	.914
X_4	.288	.908
X_5	.751	-.590
Rotation converged in3 iterations		

After rotation, the factor loads of the two common factors corresponding to each indicator tend to polarize. f_1 has a larger factor load on indicators X_1, X_2, and X_5, while f_2 has a larger factor load on indicators X_3 and X_4. The formula for calculating factor scores is as follows:

$$f_1 = 0.835X_1 + 0.955X_2 + 0.025X_3 + 0.288X_4 + 0.751X_5 \quad (1)$$

$$f_2 = 0.244X_1 + 0.169X_2 + 0.914X_3 + 0.908X_4 - 0.590X_5 \quad (2)$$

Take the proportion of annual GDP in the PRD region to the national GDP of the same year as the dependent variable (represented by data from Guangdong Province), and record it as GDP_r. Calculate the annual common factor scores within the sample range of the PRD region using formulas (1) and (2), and use two common factors instead of five indicators as explanatory variables for regression. The results obtained using the least squares method are shown in Table 5.

Table 5 Regression results using common factors f_1 and f_2 as explanatory variables

Variable	Coefficient	Std. Error	t-Statistic	Prob.
F1	-0.005744	0.017057	-0.336760	0.7462
F2	0.065362	0.025951	2.518707	0.0399
C	7.725747	1.647653	4.688939	0.0022
R-squared	0.476157	Mean dependent var		10.81311
Adjusted R-squared	0.326488	S.D. dependent var		0.349911
S.E. of regression	0.287164	Akaike info criterion		0.585798
Sum squared resid	0.577242	Schwarz criterion		0.676573
Log likelihood	0.071012	Hannan-Quinn criter.		0.486217
F-statistic	3.181393	Durbin-Watson stat		2.372746
Prob(F-statistic)	0.104041			

From Table 5, it can be seen that the p-value obtained by t-test on the regression coefficient of common factor f_1 is too large to pass the significance test. Therefore, deleting it and performing least squares regression again yields the results in Table 6.

Table 6 Regression results using f_2 as an independent explanatory variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
F2	0.063725	0.024037	2.651090	0.0292
C	7.413888	1.285053	5.769324	0.0004
R-squared	0.467670	Mean dependent var		10.81311
Adjusted R-squared	0.401129	S.D. dependent var		0.349911
S.E. of regression	0.270784	Akaike info criterion		0.401869
Sum squared resid	0.586593	Schwarz criterion		0.462386
Log likelihood	-0.009344	Hannan-Quinn criter.		0.335482
F-statistic	7.028280	Durbin-Watson stat		2.436595
Prob(F-statistic)	0.029206			

The common factor f_2 of the regression coefficient passes the test at a significance level of 0.05%, that is, f_2 affects GDP_r has a significant impact, combined with the factor load calculated earlier, the relationship between GDP_r and X_1 - X_5 is obtained:

$$\begin{aligned} GDP\_r &= 7.413888 + 0.063725 * f_2 \\ &= 7.413888 + 0.015549 * X_1 + 0.01077 * X_2 + 0.058245 * X_3 \\ &+ 0.057862 * X_4 - 0.0376 * X_5 \end{aligned} \tag{3}$$

Since the explained variable (GDP_r) is the ratio of the GDP of the PRD region to the GDP, the regression results show that: The regression coefficients of X_3 and X_4 variables are positive, which are 0.058245 and 0.057862 respectively, indicating that the innovation effect of high-tech industry agglomeration and high-tech talent agglomeration effect in the PRD region play a great role in promoting the local economic growth; The regression coefficients of X_1 and X_2 are 0.015549 and 0.01077 respectively. Although the values are relatively small, they are both positive, reflecting that high-tech industry, like other traditional industries, can increase income by reducing the operation and transaction costs of enterprises in the agglomeration area and improving production efficiency, so as to promote regional economic growth; The regression coefficient of variable X_5 is -0.0376, indicating that the "brand" effect has not promoted the economic growth of the PRD region in the past decade. The reason may be that when the agglomeration level of high-tech industries in the region reaches a certain level, the expansion of agglomeration scale and further improvement of agglomeration level will form a crowding effect (Xu and Yu, 2021)[11]. The "brand" effect of agglomeration areas plays an important role in attracting investment in the agglomeration areas in the early stage of development. The Pearl River Delta is one of the earliest regions to develop high-tech

industries in China, and it has been in a highly agglomeration state in the past decade. The production of similar products by enterprises in the agglomeration area will intensify the price competition among high-tech enterprises and decrease the efficiency of resource utilization. Some enterprises may suffer from innovation inertia and free riding.

5 Conclusions and Suggestions

By summarizing the mechanism of industrial agglomeration, this paper analyzes the significant characteristics of high-tech industry with knowledge density and knowledge spillover speed faster than traditional industries, summarizes the multiple economic effects of high-tech industry agglomeration, and expresses the multiple effects of high-tech industry agglomeration with five indicators. Factor analysis and regression analysis are used to analyze the influence of multiple economic effects of high-tech industry agglomeration on regional economic growth in the Pearl River Delta regiion, and the conclusions are as follows: In recent ten years, the innovation effect and the agglomeration of high-tech talents have the most obvious promoting effect on regional economy. The low cost and high productivity of enterprises in the agglomeration area are also important factors to promote regional economic growth, while the "brand" effect does not promote regional economic growth. Based on this, this article suggests that the Pearl River Delta region should continue to pay attention to the innovative effect of high-tech industry agglomeration and high-tech talent agglomeration, establish a scientific and technological innovation mechanism to encourage continuous innovation in high-tech industry departments, strengthen cooperation between industry, academia, and research, improve the conversion rate of scientific and technological achievements so as to continue to promote regional economic growth.

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