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Analysis of the relationship between industrial agglomeration and regional economic growth based on the multi-objective optimisation model

Zetian Chen[†]

School of Economics and Finance, South China University of Technology Guangdong,
Guangzhou, 510641, China

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Abstract

Against the background of the new era, with improvement at the socio-economic development level, scientific research scholars have begun to analyse the relations between industry agglomeration and regional economic growth, and thus of innovation for different parts of the industry upgrading and economic development to provide effective countermeasure. In order to promote the development of the regional economy in our country, there can be coordinated development. Therefore, on the basis of understanding the research status of the relationship between industrial agglomeration and regional economic growth at home and abroad, according to the multi-objective optimisation model and structural equation model, this paper conducts an in-depth discussion of the two, and finally concludes that industrial agglomeration will further promote regional economic growth.

Keywords: multi-objective, optimisation model, industrial agglomeration, regional economic growth, structural equation model.

1 Introduction

Since the era of neoclassical economics, economists around the world have paid more and more attention to the phenomenon of industrial agglomeration. The term “accumulation” was originally coined in the early 1920s by Marshall, and is mainly used in this paper to mean the geographical position of close enterprise and industry concentration. A few words can produce positive external effects, and can be technology spillovers from labour, intermediate products, three aspects of analysis the cause of the industry gathered. With the constant improvement in the industry agglomeration theory, in the mid-1990s Porter and others put forward the typical “diamond” model during the study of national competitive advantage. There is clear information about the industry agglomeration influence on international competitiveness in the regional industry; industrial concentration can further

[†]Corresponding author.

Email address: 1395845531@qq.com

enhance the level of regional competition and increase economic speed. At present, there is no systematic theoretical system for research on the relationship between industrial agglomeration and regional economic growth, and most of them mainly exist in different disciplines such as neoclassical economics, regional economics and development economics. However, since the middle and late 1990s, especially in recent years, China has begun to conduct in-depth research on the phenomenon of industrial agglomeration, and has made some achievements. Generally speaking, the core research of Chinese researchers on industrial clusters at the present stage mainly focuses on the phenomenon of industrial clusters and the in-depth exploration of relevant theories of Western scholars. For example, on the basis of studying and introducing the evolution of the theory of enterprise community abroad, Feng Delian and Wang Lei et al. sort out and analyse the relevant enlightenment according to the development trend of regional economy and industry in China. Yang Baoliang integration in the domestic market, under the guidance of geographic gathered from industry and under the open economy of the two aspects of industry agglomeration and international trade, the increasingly innovation system to study the geography environment industry gathered phenomenon and the international economic and trade problems, and find the main industrial geographic concentration of the overall upward trend. From the perspective of the development of multinational enterprises, Ren Shenggang et al. made an in-depth discussion on the dynamic evolution process of their participation in clusters. In the opinion of Wang Jici and others, industrial agglomeration can only be considered from the perspectives of economics, sociology and innovation, and has unique advantages to promote the rapid development of regional economy and enhance their own competitiveness. Nowadays, industrial agglomeration, as the focus of research scholars at home and abroad, has attracted the attention of scholars in different fields and started to conduct in-depth discussion from multiple perspectives. However, after understanding the relevant literature, it is found that there are few related topics that consider the relationship between industrial agglomeration and regional economic growth from the perspective of economic openness, which makes it difficult to correctly consider the real causes of industrial agglomeration in various places from a macro perspective. Against the background of the new era, with the increase of content and form of financial data, the traditional technology concept has been unable to meet the demands of practice development, so research scholars in their experiments to explore based on multi-objective optimisation theory put forward the quantitative trading strategy generated, as shown in Figure 1, the technical methods, and in the insurance, fund, stock and other financial products market brought about a positive role [1, 2]. Therefore, this paper also uses the multi-objective optimisation model to conduct in-depth discussion on the relationship between industrial agglomeration and regional economic growth, in order to provide an effective basis for subsequent scientific research and exploration [3].

2 Method

2.1 Multi-objective optimisation model

For the multi-objective optimisation model, the existence of a solution is very complex, because there is a certain complexity between the objective function and the multi-personality. Because the objective function cannot reach the maximum or minimum values at the same time under many conditions, it is difficult to obtain the optimal solution for multi-objective problems. However, the actual problem needs to make a choice and get an optimal solution. In essence, the optimal solution refers to the point that conforms to the constraint conditions and allows all objective functions to reach the maximum or minimum value, which belongs to the optimal solution of the multi-objective optimisation problem. Generally speaking, even if there is an optimal solution for a multi-objective optimisation problem, the computational process is also very difficult, so it needs to be studied by using a search method. In order to satisfy the calculation requirements of the optimal solution, several new conditions need to be proposed to obtain the conditional optimal solution. The usual ways are mainly divided into the following [4]:

Definition 1. First, the single objective solution. The original multi-objective optimisation problem contains

Fig. 1 Quantitative trading strategy generation technology method based on multi-objective optimisation theory

multiple objective functions into the objective optimisation problem with only one objective function. The specific ideas are as follows:

First, build a new target function:

$$f = f(f_1, f_2, \dots, f_s)$$

Proof. Comply with the property requirements: within the scope of constraint conditions. The above objective function $f = f(f_1, f_2, \dots, f_s)$ belongs to the monotonic increment function of . It should be noted that, in the construction of the new objective function, it should also be analysed in combination with practical problems, and the $f = f(f_1, f_2, \dots, f_s)$ is defined as the $f_1, f_2, \dots, f_s$ undecreasing function.

Theorem 1. Second, the objective optimisation mathematical model should be constructed

The objective function is

$$\min f = f(f_1, f_2, \dots, f_s)$$

The constraint condition is

$$g_i(x_1, x_2, \dots, x_n) = 0, i = 1, 2, \dots, m$$

Proof. Finally, the mathematical model of multi-objective optimisation is calculated, and the optimal solution or conditional optimal solution of the original multi-objective optimisation problem is obtained.

In order to better calculate the optimal solution of the single objective function, the following theorems should be combined to study the relationship between the two:

Assuming that $f = f(f_1, f_2, \dots, f_s)$ is the monotone increasing function of $f_1, f_2, \dots, f_s$, then the original multi-objective optimisation problem has an optimal solution, and the corresponding single-objective function

optimisation problem is as follows:

$$\min f = f(f_1, f_2, \dots, f_s)$$

$$g_i(x_1, x_2, \dots, x_n) = 0 \quad i = 1, 2, \dots, m$$

Proposition 2 There is a certain optimal solution which is also the optimal solution of the original multi-objective optimisation problem.

Assuming that the optimal solution of the original multi-objective optimisation problem is X^* , then the objective function in this region $f_1, f_2, \dots, f_s$ can obtain the minimum value.

Lemma 3. Assuming that the optimal solution of the single-objective optimisation problem is Y^* , then the objective function in this region can obtain the minimum value $f(Y^*)$.

Proof. It can be concluded that:

$$\begin{aligned} f_i(X^*) &\leq f_i(Y^*) \quad i = 1, 2, \dots, s \\ f(X^*) &\geq f(Y^*) \end{aligned}$$

And because $f(f_1, f_2, \dots, f_s)$ is the monotone increasing function of $f_1, f_2, \dots, f_s$, according to the analysis of the above results, we can get: $f(X^*) \leq f(Y^*)$

and $f(X^*) = f(Y^*)$

Therefore, we can get:

$$f_i(X^*) = f_i(Y^*) \quad i = 1, 2, \dots, s$$

Corollary 4. Thus, Y^* represents the optimal solution of the original multi-objective optimisation problem. From the point of view of the common objective function of single objective, it can be seen that when the multi-objective optimisation problem does not have the optimal solution, the design of objective function is the most important to obtain the conditional optimal solution by using the solution method of bullet screen package. The new objective function can directly show the relationship between the original multiple objectives, so it must be combined with real problems to design, in order to intuitively and accurately show the properties of the actual problems. Here are some common forms of the objective function:

Equilibrium optimisation function is:

$$f(f_1, f_2, \dots, f_s) = f_1 + f_2 + \dots + f_s$$

Proof. The weight optimisation function is:

$$f(f_1, f_2, \dots, f_s) = \omega_1 f_1 + \omega_2 f_2 + \dots + \omega_s f_s$$

And $\omega_1, \omega_2, \dots, \omega_s$ are all weight coefficients greater than 0

The optimisation function of the sum of squares is:

$$f(f_1, f_2, \dots, f_s) = \sum_{i=1}^s f_i^2$$

And are all weight coefficients greater than 0

Conjecture 5. Second, multiple optimisation method.

Combined with the property analysis of the actual problem, the original multi-objective optimisation problem is transformed into multiple single-objective optimisation problem. This calculation method needs to be combined with the analysis of the objective function properties of the packet optimisation problem, and thus clear the objective and order to be optimised. At the same time, multiple optimisation mathematical models should be built, as shown below:

Proof. The first optimisation is as follows:

$$\min f = f(f_1, f_2, \dots, f_s) \text{ where } f_i \text{ is some function in } f_1, f_2, \dots, f_s$$

$$g_i(x_1, x_2, \dots, x_n) = 0 \quad i = 1, 2, \dots, m$$

The solution set D_1 is then computed

Example 6. The second optimisation is as follows:

$$\min f_{i_2}(x_1, x_2, \dots, x_n) \text{ where } f_{i_2} \text{ is some function in } f_1, f_2, \dots, f_s \\ (x_1, x_2, \dots, x_n) \in D_1$$

Proof. The solution set D_2 is then computed.

Similarly, S -repeat optimisation is carried out, then the S -repeat optimisation is:

$$\min f_i(x_1, x_2, \dots, x_n) \\ (x_1, x_2, \dots, x_n) \in D_{s-1}$$

The solution set, DS , is the set of optimal solutions for multiple optimisation problems.

In other words, the optimal solution set or conditional optimal solution set of the original multi-objective optimisation problem is DS . It should be noted that it is not necessary to carry out multiple optimisation for all objective functions, but it can also carry out multiple optimisation according to certain objective functions, or even only need to select a certain objective function for optimisation.

Note 7. Third is the target correlation function method.

In the calculation and analysis based on the mathematical model of multi-objective optimisation problem, it is assumed that only a certain objective function is selected as the target, and the other objective functions are called constants within the expected value range, then the following mathematical model can be obtained:

Proof. Where f represents one of the target functions.

$$f_{i_k}(x_1, x_2, \dots, x_n) = a_{i_k} \quad k = 2, 3, \dots, s$$

Among them, $I1, I2, I3, \dots, IS$ stands for $1, 2, \dots, s$ Some permutation of s

$$g_i(x_1, x_2, \dots, x_n) = 0 \quad i = 1, 2, \dots, m$$

Assuming that there is an optimal solution to the above problem, then $\min f_1(x_1, x_2, \dots, x_n)$ is directly related to the value range of the objective function. In other words, the calculation method of the objective correlation function is to fix the value range of the objective function of one part, so as to obtain the optimal solution of the objective function of another part. Thus, the optimisation mathematical model of the binocular object is as follows:

$$\min f_1(x_1, x_2, \dots, x_n)$$

$$\min f_2(x_1, x_2, \dots, x_n)$$

$$g_i(x_1, x_2, \dots, x_n) = 0 \quad i = 1, 2, \dots, m$$

Assuming that the optimal value $\min f_1(x_1, x_2, \dots, x_n)$ is F , then F is a function of t , and $F = F(t)$ can also be obtained. Thus, this function can be called the objective correlation function of the first objective function with respect to the second objective function, and also the objective correlation function of the primary objective with respect to the sub-objective. It should be noted that the value range of t can be analysed as follows:

$$\min f_2(x_1, x_2, \dots, x_n) \leq t \leq \max f_2(x_1, x_2, \dots, x_n)$$

Assuming that the correlation function of the first objective with respect to the second objective is $F = F(t)$, then there is an optimal solution for the original dual-objective optimisation problem, which can be obtained at the corresponding point in $t = \min f_2(x_1, x_2, \dots, x_n)$. If the objective correlation function $F = F(t)$ cannot obtain the minimum value in the $t = \min f_2(x_1, x_2, \dots, x_n)$ region, then there is no optimal solution for the original dual-objective optimisation problem. When a fixed value t is studied, the value point range of the objective correlation function $F = F(t)$ is the conditional optimal solution obtained by the original dual-objective optimisation problem under the condition of a fixed second objective.

When considering the superior and inferior solutions, it is assumed that X^* and Y^* represent feasible solutions, and if the following conditions are met, X^* is a better solution than Y^* .

$$f_1(X^*) \leq f_1(Y^*), f_2(X^*) < f_2(Y^*)$$

$$f_1(X^*) < f_1(Y^*), f_2(X^*) \leq f_2(Y^*)$$

2.2 Analysis of industrial agglomeration in regional economic growth

Combined with the analysis of the multi-objective optimisation model, the following hypotheses are obtained:

First, opening to the outside world has a positive and direct impact on the composition of industrial agglomeration; second, the regional economic growth of opening to the outside world has a positive impact on the role; third, industrial agglomeration has a positive and positive effect on the factor level of the agglomeration area. Fourth, industrial agglomeration has a positive and positive effect on regional growth; Fifth, factor input has a positive effect on the regional economic growth. In this paper, 4 latent variables and 11 observed variables are proposed, and their specific contents and meanings are shown in Table 1 [5, 6]:

At the same time, combined with the assumptions and variables proposed in this study, the equation model as shown in Figure 2 can be obtained:

Due to the high requirement of model research on the number of samples, the practical analysis takes prefecture-level cities in China as the research target and carries out cross-section research on the basis of collecting and accumulating relevant data. Finally, the sample size reaches 283, which is mainly derived from the statistical yearbooks of provinces and cities.

During the data analysis and processing, in order to avoid the phenomenon of false regression caused by unstable variables, this paper implemented unit root detection for all variables using the ADF method. Assuming that the variables are stationary, the following analysis can be performed directly. Otherwise, relationship testing shall be conducted in accordance with the specified requirements, and the final test results are as shown in Table 2 [7]:

Combined with the analysis in Table 2, it can be seen that most variables are controlled at the significance level of 1%, which meets the requirements of unit root test, and the single integer order is 0. It is proved that all the variables in the unit root test results belong to a stationary sequence and meet the basic requirements of equation model analysis, so subsequent analysis can be carried out [8].

In the normal distribution test, the maximum likelihood estimation method should be used for research, and all variables should conform to the normal distribution. The final results are shown in Table 3.

3 Result analysis

The analysis path shown in Figure 2 is studied using the AMOS7.0 software and estimated data to analyse the model data. Combined with the above picture analysis, it can be seen that the Chi-square test probability value of the model outlined in this paper is 0.215, which is more than 0.05, which proves that the model fitting data conforms to the original hypothesis. At the same time, combined with the analysis of parameter estimation results as shown in Table 4, it can be seen that model evaluation should first judge whether the parameters

Table 1 Connotation analysis of latent variables and observed variables

Latent variables	Observed variables	Variable meaning
Economic growth	Per capita gross regional product (RJGDP) (yuan)	Ratio of GDP to total population at year-end
	Average salary (PJGZ) (Yuan)	Weighted average wages of state-owned units, urban collective units and other units
	Per capita fiscal revenue (RJCZSR) (yuan)	Ratio of annual general budget revenue to year-end population
Industrial agglomeration	Proportion of industrial added value (GYBZ) (%)	The proportion of industrial added value in regional GDP
	Proportion of Manufacturing Enterprises (CYRS) (%)	Proportion of the number of manufacturing enterprises in the total number of regional enterprises
	Agglomeration Index (JJZS)	Calculate according to relevant formulas
Opening to the outside world	Proportion of Actual Utilisation of Foreign Investment (SJLYWZ) (%)	The proportion of FDI actually utilised in GDP
	Proportion of Processing Trade (JGMYBZ) (%)	Processing trade as a share of a region's total foreign trade, which also measures the extent to which a region is integrated into the global production network
	Trade Dependence (MyYCD) (%)	Ratio of total regional imports and exports to GDP
Factor input	Growth of Fixed Asset Investment (GDZCTZ) (%)	(Total Fixed Assets Investment of Current Year – Total Fixed Assets Investment of Last Year)/Total Fixed Assets Investment of Last Year – 1
	Human capital (RLZB) (%)	Growth rate of employment at year-end

Table 2 Analysis of test results based on ADF unit root

Variable	Test statistics	P values	Lag	The whole order
Rjgdp	-4.473965	0.0003	0	I(0)
Pjgz	-5.019404	0.0002	0	I(0)
Rjczsr	-4.965987	0.0003	0	I(0)
Gybz	-3.573293	0.0068	11	I(0)
Cyrs	-3.979609	0.0017	11	I(0)
Jjzs	-5.419012	0	0	I(0)
Sjlywz	-4.460539	0.0003	0	I(0)
Jgmybz	-4.455309	0.0003	0	I(0)
Myycd	-5.131048	0	0	I(0)
Gdzctz	-4.145615	0.00015	0	I(0)
RLzd	-5.241372	0.00024	0	I(0)

Fig. 2 Structure diagram of equation model

Table 3 Test and analysis results of normalised data

	Pjgz	Rigdp	Jgmybz	Silywz	Mzzcd	Gybz	Cyrs	Jjzs	Rjczs	Gdzctz	Rlzb
N	283	283	283	283	283	283	283	283	283	283	283
Mean	1.84	1.41	48.6	2.87	64.13	47.3	23.86	1.28	24.19	25.7	5.89
SD	1.0064	0.0539	0.1544	0.1915	0.0744	0.264	0.0038	0.0362	0.1464	0.1028	0.0546
Skewness	0.0001	0	0	0	0	0	0.0002	0	0	0	0
Kurtosis	2.9704	2.9714	2.9705	2.9725	2.9732	2.9687	2.9745	2.9709	2.9689	2.9704	2.9717
Jarque Bera	0.0120	0.0116	0.0118	0.0117	0.0124	0.0117	0.0106	0.0113	0.0116	0.0115	0.0135
Probability	0.9941	0.9942	0.9938	0.9924	0.9854	0.9868	0.9947	0.9944	0.9958	0.9524	0.9673

contained in it have statistical significance, and then conduct significance test and analysis on each coefficient. In this paper, a simple test method in AMOS 7.0 was selected as CR, and it was found that the significance test of the final parameters and variance results was completed [9].

It can be seen that the first hypothesis proposed in this paper is valid, and the opening to the outside world has a direct impact on the phenomenon of industrial agglomeration, and the corresponding influence coefficient reaches 0.12. The significance level of the second hypothesis put forward in this paper reaches 0.034, which proves that the hypothesis is valid and has direct and indirect effects on economic growth. The significance level of the third hypothesis proposed in this paper reaches 0.004, which proves that the hypothesis is also valid, and the direct influence coefficient of industrial agglomeration on the accumulation of factors reaches 0.3. Therefore, it can be seen that industrial agglomeration can lead to the agglomeration of population, technology,

Table 4 Parameter estimation analysis results

	The normalised path coefficient	S.E	C.R	P
Industrial agglomeration < – Opening to the outside world	123	139	924	003
Factor input < – Industrial agglomeration	301	165	966	034
Economic growth < – Industrial agglomeration	467	302	2.877	004
Economic growth < – factor input	073	704	363	002
Economic growth < – Opening to the outside world	005	252	041	006
Jgmybz< – Opening to the outside world	301	215	2.066	039
Myycd< – Opening to the outside world	974	219	1.135	026
Sjlywz< – Opening to the outside world	378			
Gybz< – Industrial agglomeration	830	161	8.294	***
Jjzs< – Industrial agglomeration	847	268	8.476	***
Pjgz< – Economic growth	648	120	4.246	***
Rjgdp< – Economic growth	732			
Gdzctz< – factor input	390			
Rlzd< – factor input	644	2.888	944	045
Rjczsr< – Economic growth	706	193	4.385	***
Cyrs< – Industrial agglomeration	871			
Note: ※※※ $P < 0.001$				

capital and other factors. Hypothesis 4 proposed in this paper is also valid, and the actual significance level reaches 0.002. Based on the analysis from the perspective of practical development, the influencing factors of industrial agglomeration on regional economic growth can be divided into two situations: one is direct influence, the other is indirect influence, and the direct influence of industrial agglomeration on economic growth is greater; in Hypothesis 5, factor input also has a direct impact on the regional economic growth, and the significance level reaches 0.006. But from a practical point of view, the impact is small. At the same time, combined with the analysis of observation variables proposed in this paper, it can be seen that industrial agglomeration is closely related to regional economic growth, and will form a direct or indirect impact from multiple perspectives.

4 Conclusion

To sum up, in the new era, in order to grasp better the relationship between regional economic growth and industrial optimisation and upgrading, researchers should start from the multi-objective optimisation model to strengthen the research on the relationship between the two, and pay attention to learning from the conclusions of research topics at home and abroad, so as to put forward effective suggestions for the current economic development.

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