Analysis of Influencing Factors of Total Foreign Direct Investment Based on Grey Relational Analysis

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Abstract: *After China joined the WTO, the level of China's opening to the outside world has gradually increased, and the total foreign direct investment has shown an upward trend. The inflow of high-quality foreign capital will help promote the growth of China's consumption, investment and total imports and exports, and stimulate economic development. At the same time, the growth of total foreign direct investment can also further promote the level of China's opening to the outside world. This paper uses the grey relational analysis method to conduct an empirical analysis on the index system composed of the influencing factors of the national total foreign direct investment. The research shows that each index in the index system has different degrees of influence on the total foreign direct investment. This article starts from the influencing factors, and formulates corresponding suggestions for the country to formulate the opening-up policy.*

Keywords: *total foreign direct investment, grey relational analysis, indicator system*

1. Introduction

Since the Reform and Opening Up, China has deepened its high-level opening to the outside world and has continuously relaxed foreign investment access. From 2017 to 2020, the negative list of national and pilot free trade zones was revised for four consecutive years, providing a broader development space for foreign investment. However, after the outbreak of the global epidemic, cross-border investment in 2020 has declined sharply. At the same time, unilateralism and protectionism have risen, and the economy has encountered a trend of de-globalization. Foreign direct investment can drive the growth of the national economy and improve the level of the country's opening to the outside world. In the face of the severe international situation, China chooses to continue to promote the inflow of foreign capital. On December 27, 2021, the National Development and Reform Commission and the Ministry of Commerce issued the "Special Administrative Measures for Foreign Investment Access (Negative List) (2021 Edition)" and "Special Administrative Measures for Foreign Investment Access in Pilot Trade Zones (Negative List) (2021 Edition) ". In the context of the epidemic of the century, how to make the total foreign direct investment continue to grow has become an important issue.

The introduction of high-quality foreign capital can effectively promote China's foreign trade development and capital circulation, but the theoretical research in this area is not perfect. This paper constructs an index system by synthesizing the influencing factors of the total foreign direct investment, and uses the grey correlation method to deeply analyze the correlation between each influencing factor and the national total foreign direct investment, so as to put forward effective suggestions for further improving the level of the total foreign direct investment.

2. Analysis of research status

In recent years, scholars have continued to conduct various studies on the total amount of foreign direct investment. Sun Gangqiang et al. [1] analyzed the influencing factors of foreign investment by using a factor analysis model. The results show that the inflow of foreign capital is mainly determined by the comprehensive factor of the domestic economic development level. The impact of internal imbalance on the actual utilization of foreign capital is negative, and the external imbalance caused by the expansion of surplus, will be conducive to attracting foreign capital, and proposes that economic development,

appropriate expansion of surplus or reduction of deficit, and maintaining the basic stability of the RMB exchange rate within the equilibrium range can attract foreign capital inflows. Jiang Hao[2] analyzed the impact of foreign direct investment on industrial upgrading through panel fixed model, random effect model, DEA model, panel threshold regression model, and spatial econometric model. The results show that FDI has an obvious threshold effect on industrial upgrading. There is a significant positive spatial autocorrelation in industrial upgrading, and the spatial spillover effect of foreign direct investment needs to be improved. Zhao Mingyue[3] studies the policy-driven and industry productivity of foreign direct investment through the breakpoint regression model and the five-part decomposition of FHK productivity. The effect is more significant. Ma Sirui[4] analyzes the impact of tax policies on foreign direct investment through the method of comparative analysis, and puts forward suggestions for foreign direct investment enterprises in China's tax policy at the current stage in connection with China's current specific needs for economic structure development and the objective economic environment.

Chen Can et al.[5] analyzed whether foreign direct investment has an impact on the income gap in the Pan-Pearl River Delta region through a fixed-effect regression model, and found that foreign direct investment has a positive correlation with the overall urban-rural income gap in the Pan-Pearl River Delta region. Li Yan[6] analyzed the impact of foreign direct investment into Shandong Province on the total employment in the next two years through a time series model, and found that foreign direct investment will have a negative impact on employment in the short term, and the negative impact will gradually tend to zero after three years, and make relevant recommendations. Li Xiaolei[7] analyzed the influence and function of foreign direct investment on Hebei's industrial structure through grey relational analysis and regression analysis, and found that foreign direct investment played an important role in Hebei's economic development and promoted the adjustment of industrial structure. Zhang Sen[8] analyzed the relationship between FDI and economic development by means of econometric methods such as unit root test and cointegration test, and found that the demand effect of FDI can promote the economic growth of Beijing, and the growth of FDI can help Beijing's import and export trade effect, foreign investment can mobilize the enthusiasm of the labor force. Mao Xiangshi[9] analyzed the influencing factors of the location distribution of foreign direct investment in Yunnan Province through a dynamic panel model. The results show that there is a significant positive correlation between the foreign direct investment, market size, and the industrial agglomeration of the three industries with a lag period of one period and the foreign direct investment of cities and prefectures in Yunnan Province, and labor prices have a significant negative correlation with foreign direct investment in cities and states of Yunnan Province. The influence of transportation infrastructure and economic openness on the location distribution of foreign direct investment in Yunnan Province is not significant.

To sum up, at present, scholars have conducted more and wider research on foreign direct investment, and their research results are reflected at the theoretical and empirical levels. Synthesizing the existing literature on foreign direct investment research, we can see that the existing literature has three deficiencies. First, the scope of the study is mostly regional rather than national. Regions also need high-quality theoretical guidance for the introduction of foreign capital, but under the international background of a century of changes in the world and the intertwined epidemic of the century, unilateralism and protectionism are on the rise, and economic globalization is encountering adverse currents, thus how can the total amount of foreign direct investment in the country further increase becomes one of the important topics we need to study urgently. The way to increase the total amount of foreign direct investment is different for the whole country and for the region. Therefore, it is more conducive to propose solutions to this issue based on the research on the factors affecting the total amount of foreign direct investment nationwide. Second, some literatures only study the impact of changes in total foreign direct investment on other aspects, but do not study the impact of other aspects on total foreign direct investment. These literatures cannot directly point out the factors affecting the total amount of foreign direct investment, so they cannot directly put forward suggestions for improving the level of foreign investment in the country. Finally, based on the existing literature, it is found that when scholars select indicators, they tend to select multiple indicators in one aspect, and less indicators are selected for corporate tax burden, infrastructure construction and other aspects. Based on the research of the existing literature, this paper overcomes the above three deficiencies, comprehensively selects the influencing factors from various aspects to construct an index system, and calculates the relationship between the total foreign direct investment and each index in the index system through the grey relational analysis method. The correlation degree is analyzed according to the empirical results, which provides a theoretical basis for the country to formulate relevant policies, so as to promote the continuous growth of the total amount of foreign direct investment in the country.

3. Data selection

This paper selects the actual use of foreign capital in the country from 2001 to 2020 as an indicator to reflect the total amount of foreign direct investment in China, selects GDP per capita as an indicator of national economic development, and selects the proportion of three industrial outputs in GDP as an indicator of industrial structure. The total import and export tariffs are used as an indicator to reflect the degree of trade barriers, the proportion of total imports and exports to GDP is selected as an indicator to reflect the degree of trade openness, the number of patent applications granted is selected as an indicator to reflect the technical level, and the average wage of employees in urban non-private units is selected as an index reflecting labor costs, the turnover of goods is selected as an index reflecting infrastructure conditions, and the tax amount of foreign-invested enterprises is selected as an index reflecting tax burden, so as to construct an index system of Table 1. The data comes from the "China Statistical Yearbook", "2021 China Foreign Investment Statistical Bulletin" and "Nanjing Statistical Yearbook". This paper draws on other scholars' research on the factors of total foreign direct investment[1].

Table 1: Index System of Factors Influencing Total Foreign Direct Investment

target layer	feature layer	Indicator layer
total foreign direct investment	Economic development	GDP per capita (yuan)
	Industrial structure	Percentage of primary industry in GDP (%)
		The proportion of secondary industry in GDP (%)
		The proportion of the tertiary industry to GDP (%)
	Foreign trade	Total import and export tariffs (100 million yuan)
		The proportion of total imports and exports to GDP (%)
	Technology	Number of granted patent applications (pieces)
	Labor force	Average wages of employees in urban non-private units (yuan)
	Infrastructure	Cargo turnover (100 million ton-kilometers)
	Tax	Tax amount of foreign-invested enterprises (100 million yuan)

4. Model options

This paper studies the correlation between the total foreign direct investment and the index system composed of economic development, industrial structure, foreign trade and so on through the grey correlation analysis method. Grey system theory is a marginal subject founded by Professor Deng Julong of Huazhong University of Science and Technology in 1982. As the most important part of grey system theory, grey relational analysis method aims to obtain the degree of correlation between various factors through quantitative research. Gray system is a system with incomplete information, referred to as gray system. The grey relational method can overcome the shortcomings of traditional mathematical methods, such as: requiring a large amount of data; requiring the sample to obey a typical probability distribution; requiring a linear relationship between each factor data and the system characteristic data. This method has a small amount of calculation, which makes it easy to use, and does not make conflict between quantitative results and qualitative analysis results.

Grey relational analysis judges the closeness of the connection between sequence curves according to the similarity degree of their geometric shapes. In the process of system development, if the trends of the two factors are consistent, that is, the geometric shapes of the curves are similar, the degree of correlation between the two is high; otherwise, it is low.

The steps of grey relational analysis are as follows:

(1) Determine the analysis sequence. The parent sequence is the data sequence that can reflect the behavioral characteristics of the system. Let the parent sequence be

$$x_0 = \{x_0(k) | k = 1, 2, \cdots n\}$$

Which k represents the time. A subsequence is a data sequence composed of factors that affect the behavior of the system. Assuming there is m a subsequence, let the parent sequence be

$$x_0 = \{x_i(k) | k = 1, 2, \cdots, n, i = 1, 2, \cdots, m\}$$

In this paper, the actual amount of foreign capital used in the country is selected as the parent sequence, and each index value in the index system is used as the subsequence.

(2) Initialize the variable. Due to the different meanings of the factors in the system and the different dimensions of the data, it is difficult to draw correct conclusions when comparing. The variable value range is large and inconsistent, and the calculation needs to be simplified by narrowing the value range. Therefore, this paper preprocesses the data of each indicator before conducting the grey relational analysis. Since each indicator in the indicator system is a positive indicator, the original sequence is initialized in the following way.

$$x_0(t) = \frac{x_0(t)}{\frac{1}{n}\sum_{t=1}^{n} x_0(t)}, x_i(t) = \frac{x_i(t)}{\frac{1}{n}\sum_{t=1}^{n} x_i(t)}$$

(3) Find the absolute difference sequence of the subsequence and the parent sequence and the two-level minimum difference and the two-level maximum difference. That is, the absolute difference of the index data is listed $|x_0(t) - x_s(t)|$, the minimum difference between $\min_s \min_t |x_o(t) - x_s(t)|$ the two levels is , and the maximum difference between the two levels is $\max_s \max_t |x_o(t) - x_s(t)|$.

(4) Calculate the correlation coefficient.

$$\xi_i(k) = \frac{\min_s \min_t |x_0(t) - x_s(t)| + \rho \max_s \max_t |x_0(t) - x_s(t)|}{|x_0(k) - x_i(k)| + \rho \max_s \max_t |x_0(t) - x_s(k)|}$$

Represents the correlation coefficient between the subsequence x_i and the parent sequence x_0 at the k moment, which $\rho \in [0,1]$ is the resolution coefficient. Generally speaking, the larger the resolution coefficient ρ, the larger the resolution; the ρ smaller the resolution, the smaller the resolution. This paper takes ρ it as 0.5.

(5) Calculate the correlation degree. The degree of association reflects the degree of association between the subsequence and the parent sequence at a certain moment. Since there is a correlation number at each moment, the information is too scattered, so the establishment of the correlation index can collect the correlation coefficient at each moment into an average value, which is $r_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k)$ called the gray correlation degree.

(6) Sort the grey relational degree. When there is one comparison sequence m, there is also a gray correlation degree m, which is arranged according to its value, reflecting the pros and cons of each subsequence to the parent sequence.

5. Empirical Analysis

This paper selects the total amount of foreign direct investment from 2001 to 2020 as the dependent variable x_0, selects 10 indicators in the same period as independent variables $x_1 \sim x_{10}$ (explaining variables), uses MATLAB R2020a to calculate the gray correlation degree of the data, and ranks the gray correlation degree according to the results. The relationship between total foreign direct investment and 10 indicators such as economic development, industrial structure, foreign trade, and technological level is analyzed. The greater the correlation, the closer the relationship between variables.

Table 2 Calculation results of grey relational degree

independent variable	grey relational degree	sort
GDP per capita	0.8009	5
The ratio of primary production to GDP	0.7032	10
Secondary production as a percentage of GDP	0.7589	7
The tertiary industry as a percentage of GDP	0.8246	3
Total import and export duties	0.8995	2
The ratio of total imports and exports to GDP	0.7106	9
Number of granted patent applications	0.7113	8
Average salary	0.7914	6
Cargo turnover	0.9162	1
Tax amount of foreign-invested enterprises	0.8068	4

The calculation results are shown in Table 2. According to the calculation results, the correlation between the 10 indicators calculated and the total foreign direct investment exceeds 70%, indicating that

these 10 indicators have a relatively close relationship with the total foreign direct investment. The gray correlation between each indicator and total foreign direct investment is ranked as follows: Cargo turnover > Total import and export duties > The tertiary industry as a percentage of GDP > Tax amount of foreign-invested enterprises > GDP per capita > Average wage > Secondary production as a percentage of GDP > Number of patent applications granted > The ratio of total imports and exports to GDP > The ratio of primary production to GDP.

As an indicator of national infrastructure construction, cargo turnover has the highest correlation with total foreign direct investment, indicating that national infrastructure construction, especially in transportation, has a very significant role in promoting foreign direct investment. Since the founding of the People's Republic of China, China has provided a large amount of financial support for infrastructure, and the construction of roads, railways and waterways has been continuously improved. In the future transportation construction, China will be committed to enabling advanced information technology to deeply empower transportation infrastructure, and comprehensively enhance the capabilities of accurate perception, accurate analysis, fine management and meticulous service. Advanced transportation construction can provide foreign investors with a better investment environment and effectively promote the development of foreign trade.

The total import and export tariff, as an indicator reflecting the degree of national trade barriers, has a correlation of 0.8995 with the total foreign direct investment, which is second only to the turnover of goods, indicating that the development of China's foreign trade has a relatively obvious role in promoting foreign direct investment. Since the reform and opening up, China has actively promoted free trade and firmly safeguarded the multilateral trading system. An open trade environment can not only promote the introduction of foreign capital in China, but also improve China's level of opening to the outside world.

The ratio of the tertiary industry to GDP, as an indicator reflecting the national industrial structure, has a high correlation with the total foreign direct investment, indicating that a reasonable industrial structure plays a greater role in promoting foreign direct investment. In recent years, China has accelerated the upgrading of traditional industries and vigorously developed the tertiary industry with high added value. In the future, we should continue to focus on the encouragement and support for the tertiary industry, and promote the introduction of foreign capital by optimizing the industrial structure.

6. Conclusion recommendations

From 2001 to 2020, the actual use of foreign capital in the country showed an overall growth trend. This paper selects 10 indicators related to economic development, industrial structure, degree of trade barriers, degree of trade openness, technical level, labor cost, infrastructure and tax burden, and constructs an indicator system. Empirical analysis shows that there is a close relationship between the 10 indicators in the indicator system and the total amount of foreign direct investment in the country. Starting from several influencing factors of total foreign direct investment, this paper puts forward effective suggestions to promote the steady growth of total foreign direct investment.

(1) Optimizing the foreign direct investment environment

The foreign direct investment environment includes two parts: soft environment and hard environment. The hard environment mainly includes infrastructure construction and technology. In terms of infrastructure construction, we should focus on the construction of railways, highways, airports and other transportation methods to improve transportation efficiency and provide better conditions for foreign investment. In terms of science and technology, scientific and technological innovation should be continuously encouraged to improve the utilization rate of foreign capital and attract more foreign capital. The soft environment mainly includes the degree of opening to the outside world. We should optimize the national treatment plus negative list management system, and promote the implementation of wider and deeper opening to the outside world. Under the premise of coordinating security and development, the negative list for foreign investment access shall be reasonably reduced.

(2) Reasonably reduce the tax burden of foreign-invested enterprises and reduce foreign trade barriers

High tariffs and high corporate income tax are two factors hindering the growth of total foreign direct investment. In order to attract more high-quality foreign investment into China, the taxation of foreign-funded enterprises should be reasonably reduced, and the taxation structure should be optimized at the same time. For foreign-funded enterprises in high value-added industries, such as: finance, new energy vehicles, etc., a higher degree of tax incentives should be given. Appropriately lowering tariffs to lower trade barriers and improving the trade conditions faced by foreign-funded enterprises can also effectively

attract foreign investment.

(3) While promoting economic growth, we should pay attention to the adjustment of industrial structure

Economic development is an important factor affecting the total foreign direct investment, which should be further promoted by encouraging the establishment of domestic multinational corporations and promoting domestic consumption. At the same time, pay attention to the adjustment of industrial structure, and promote the development of the tertiary industry while ensuring the existence of the primary and secondary industries. We should promote the growth of total foreign direct investment by increasing the proportion of per capita GDP and the tertiary industry.

(4) Pay attention to talent training and improve the quality of human capital

Labor costs are an important factor in total foreign direct investment, reflecting the quality of human capital. In order to increase the total amount of foreign direct investment, China should continue to strengthen the capital investment in various universities and other talent training institutions, encourage higher education, promote the spirit of innovation, and improve the quality of my country's human capital.

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