

Study on the Effect of China's OFDI on Industrial Structure Adjustment Based on Grey Relational Theory

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Abstract—Facing the rapid development of globalization, China's foreign direct investment has also increased rapidly. At present, China is in a critical period of industrial restructuring, but the industrial structure of our country is not reasonable and the overall quality is low, so it is very difficult to adjust the industrial structure. Based on the existing research at home and abroad, this paper first analyzes the present situation of China OFDI and the adjustment of industrial structure, then according to the grey relevancy theory, by constructing the grey absolute correlation degree and grey correlation degree and the comprehensive correlation degree and other related indicators, and analyses the influence of China's foreign direct investment on domestic industrial structure. The result of this study showed that the effect of different types of FDI on China's industrial structure adjustment is not consistent, proposed on this basis in our country how to more effectively use OFDI to promote the adjustment of industrial structure in China and puts forward some suggestions.

Keywords— Grey relational grade, OFDI, Industrial structure adjustment.

I. INTRODUCTION

Foreign direct investment (FDI) is the need of the development of China's economy and enterprises themselves, and also conforms to the requirements of economic globalization. Chinese enterprises with an international perspective should take the initiative to "go out". After the reform and opening up, China has actively introduced foreign direct investment and successfully integrated into the global economy by taking advantage of its comparative advantages. The 16th National Congress of the Communist Party of China clearly pointed out that the "introduction" and "going out" should be better combined to encourage and support enterprises to carry out international operations in R&D, production and sales, to participate in international economic and technological cooperation and competition in a wider range, in a wider range and at a higher level, and to make full use of both domestic and foreign enterprises. The market should optimize the allocation of resources, expand the scope of opening up and expand the development space. China's 13th Five-Year Plan clearly states that foreign investment and domestic industrial development will be promoted each other, "going out" and "introducing" complement each other, so as to make full use of the advantages of the two markets for common development.

Accelerating the adjustment of industrial structure and promoting the coordinated development of economy is not only an important issue of macroeconomic development, but also an inherent need for China to implement the scientific concept of development. Through the optimization of resource allocation structure, the overall efficiency and efficiency of the national economy can be improved. Under the condition of open economy, the adjustment of industrial structure can be realized through the international allocation of resources and the cross-border transfer of industries. OFDI has become an important and effective way to promote the adjustment of national industrial structure. In 2013, the Central Economic Work Conference proposed that in 2014 we should vigorously adjust the industrial structure, focus on solving overcapacity and implement innovation-driven development, resolutely

resolve overcapacity, implement the decision-making and deployment of the central government to eliminate overcapacity, vigorously develop strategic emerging industries and accelerate the development of various services. Industry, and promote the optimization and upgrading of traditional industries.

II. PRESENT SITUATION ANALYSIS

A. The Development Status of China's Foreign Direct Investment

In 2001, China joined the WTO and injected new upgrade and vigor into the development of China's foreign direct investment. Combining with the national strategy of "going out", China's OFDI has made rapid development in this stage, and has new characteristics in investment scale, investment industry and so on. In terms of investment scale, both stock and flow data show that China is moving towards a big country of foreign direct investment.

In 2015, China's OFDI net volume (traffic) was \$145 billion 670 million, an increase of 18.3% over the same period last year. OFDI accumulated net amount (stock) amounted to US \$1 trillion and 97 billion 860 million. In 2015, foreign direct investment in non-financial sectors was \$121.42 billion, an increase of 13.3%; sales revenue of overseas enterprises was \$138.63 billion, a decrease of 11.7%; imports and exports of domestic investors through overseas enterprises were \$313.2 billion, of which imports totaled \$204.5 billion, a decrease of 39.5%; exports totaled \$108.7 billion. At the end of 2015, the stock of foreign direct investment in non-financial sectors was \$938.2 billion, and the total assets of foreign enterprises were \$244 trillion. In addition, in recent years, the amount of OFDI in China has gradually increased, and the position of OFDI in the world has gradually increased. In 2015, China achieved a historic breakthrough in foreign direct investment, ranking second in the world for the first time, and exceeding the level of attracting foreign investment in the same period, realizing net capital export under two-way direct investment for the first time.

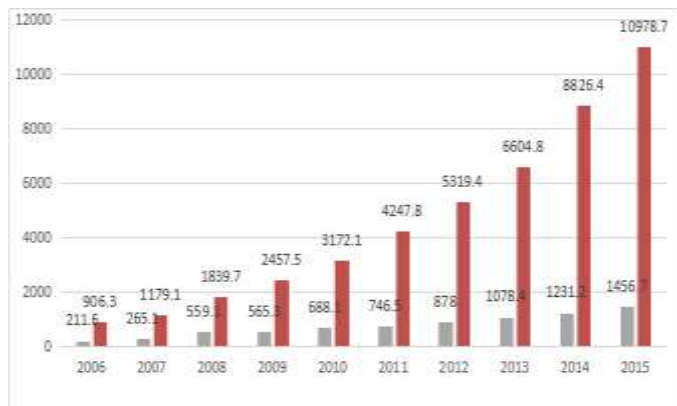


Fig. 1. 2006-2015 China's foreign direct investment stock and flow chart.

Fig. 1 shows that in 2006, China's OFDI traffic was \$21.16 billion, with a stock of \$90.63 billion; in 2015, China's OFDI traffic was \$145.67 billion, with a stock of \$1097.86 billion. From 2006 to 2015, the annual growth rate of OFDI traffic in China was 21.28%, and the annual growth rate of stock was 28.33%. This shows that our country is speeding up the pace of "going global" step by step.

B. The Development Status of China's Domestic Industrial Restructuring

The level of the three industrial structures in China is an important index to measure the level of economic development of a country, and has the characteristics of stages of economic development. Before the reform and opening up, China was a big developing country with agriculture and industry as the main part. The first and second industries occupied an important position in our national economy, and the third industry did not get good development. In the early stage of reform and opening up, China's domestic industrial structure has shown a "two, one, three" high and low trend; with the further implementation of the reform and opening up policy, China's domestic industrial structure has also undergone corresponding changes, the output value of the tertiary industry has gradually exceeded that of the primary industry and become an important force to promote domestic economic growth. The industrial structure has also changed from "two, one, three" to "two, three, one" in the early stage of reform and opening up, and has been continuing. At the beginning of the 21st century, after China's accession to the WTO, the degree of China's opening to the outside world has been further improved, and the trade activities with other countries have been increasing day by day, which has created a good opportunity for the three industrial restructuring in China. In recent years, the gap between the proportion of output value of primary and tertiary industries has been further widened, thus forming a domestic economic growth model mainly driven by secondary and tertiary industries; by 2015, the proportion of added value of the three industries in China was 8.8%, 40.9% and 50.3%, respectively, and the trend of optimizing the domestic industrial structure was obvious.

In 2015, China's OFDI covered 19 major sectors of the national economy. Among them, investment in manufacturing, finance, information transmission, software and information services increased significantly, such as \$19.99 billion in

manufacturing, up 108.5% from a year earlier, accounting for 13.7% of the total annual traffic, \$24.25 billion in finance, up 52.3% from a year earlier, and 16.6% in information transmission, software and information technology services. The business sector grew by 115.2% to 4.7%, compared with \$2.73 billion in transportation, warehousing and postal services, by 34.7%; the mining sector by 32% to \$11.25 billion; and the leasing and business services (mainly for investment holding) by \$36.26 billion, down by 1.6%.

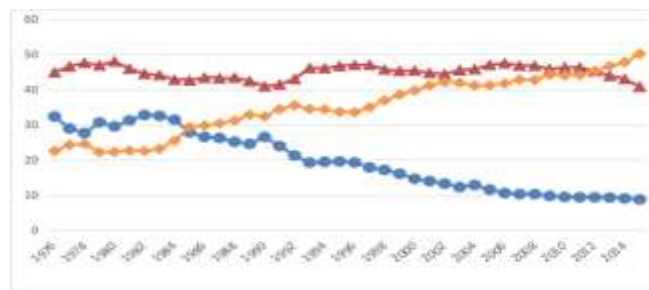


Fig. 2. 1976-2012 China's three industry value added proportion trend chart.

At the end of 2015, 75.2% of China's FDI stock was distributed in the tertiary industry (i.e. service industry), amounting to \$826.19 billion, mainly in business services, finance, wholesale and retail, transportation, warehousing, real estate and other fields. The secondary industry accounted for 26.35 billion US dollars, accounting for 24% of China's FDI stock, of which the mining industry (excluding mining ancillary activities) accounted for 14.18 billion US dollars, accounting for 53.9% of the secondary industry; the manufacturing industry (excluding metal products, machinery and equipment repair industry) 78.43 billion US dollars, accounting for 29.8%; the construction industry was US\$ 27.12 billion, accounting for 10.3%; The production and supply of electricity, heat, gas and water were US\$ 15.66 billion, accounting for 6%. The primary industries (agriculture, forestry, animal husbandry and fishery, but excluding agriculture, forestry, animal husbandry and fishery services) amounted to \$8.62 billion, accounting for 0.8% of China's FDI stock.

III. EMPIRICAL ANALYSIS

A. Industrial Structure Adjustment Effect Measure

In the process of industrial evolution, the industrial structure has gradually become rationalized and highly advanced. This paper draws on Zhou Changlin and Wei Jianliang (2007) to measure the industrial structure level, and regards division of labor and specialization as the decisive factors for the evolution of industrial structure. It believes that division of labor leads to the formation of different industries and industrial structures, and specialization can improve labor productivity and industry. The sum of the output value as a percentage of GDP and the value of each industry level is used as an indicator to measure the level of industrial structure. Since labor productivity can concentrate on the industrial level, the industrial productivity value is expressed by the labor productivity of the industry. The industrial structure adjustment measurement indicators required for this paper are expressed as:

$$I = \sum_{i=1}^3 X_i * Y_i, i = 1,2,3.$$

X_i refers to the labor productivity of each industry, $X_i = Z_i / N_i$, among Z_i, N_i respectively indicates the output value of the i industry and the number of employed people. In this paper, using dollar-denominated GDP data, the labor productivity obtained is how much dollar GDP per capita was created by the industry in that year. In order to avoid changes in high labor productivity industries to cover the changes in low labor productivity industries, the labor

productivity is pre-processed; Y_i represents the proportion of industrial output value to GDP. The revised formula is:

$$I = \sum_{i=1}^3 \sqrt{Z_i / N_i} * Y_i, i = 1,2,3.$$

$\sqrt{Z_i / N_i}$ refers to i Industry level coefficient, The size of the coefficient can reflect the level of the industry, and expresses in Li. $\sqrt{Z_i / N_i} * Y_i$ call the contribution of the industry to the level of industrial structure.

TABLE I. China's industrial structure level indicators from 2000 to 2015.

YEAR	Primary industry			Secondary industry			Tertiary Industry			Comprehen-sive level
	L1	Y1 (%)	I1	L2	Y2 (%)	I2	L3	Y3 (%)	I3	
2000	22.59	17.6	3.97	53.27	46.2	24.61	44.24	36.2	16.01	44.6
2001	22.35	16.5	3.69	54.97	45.8	25.18	46.11	37.7	17.39	46.25
2002	22.41	15.1	3.38	58.24	45.9	26.73	48.56	39	18.94	49.05
2003	22.89	14.4	3.3	60.67	45.1	27.36	51.58	40.5	20.89	51.55
2004	23.31	13.7	3.19	64.45	44.8	28.87	53.65	41.5	22.27	54.33
2005	24.09	12.8	3.08	68.84	46	31.67	55.94	41.2	23.05	57.8
2006	27.26	13.4	3.65	73.08	46.2	33.76	58.6	40.4	23.67	61.09
2007	28.58	12.1	3.46	77.6	47.4	36.78	62.45	40.5	25.29	65.53
2008	30.71	11.1	3.41	83.02	48	39.85	67.79	40.9	27.73	70.99
2009	35.04	10.8	3.78	90.48	47.3	42.8	77.45	41.9	32.45	79.04
2010	40.21	10.7	4.3	102.23	47.4	48.56	86.8	41.9	36.28	89.14
2011	42.18	10.3	4.34	104.7	46.2	48.48	91.53	43.5	39.72	92.55
2012	46.31	10.1	4.68	112.73	46.7	52.76	98.52	43.2	42.46	99.9
2013	52.46	10	5.25	123	46.6	57.32	107.9	43.4	46.83	109.39
2014	56.78	10.1	5.73	126.63	45.3	57.36	115.11	44.6	51.34	114.43
2015	59.23	8.9	5.27	131.8	40.9	53.91	121.3	50.2	60.89	120.07

B. Grey Correlation Analysis

Since 2003, China has published the annual OFDI statistical bulletin. In 2006, the OFDI industry type was unified. By 2015, there were 10 consecutive years of data, and the sample size was too small to be analyzed using mathematical statistics based on large sample data. It is suitable to use the grey relational analysis method based on the grey system theory.

The data from 2006 to 2015 is selected as the original data sequence, including the indicators of the secondary industry (i_2), the tertiary industry (i_3) and the comprehensive industrial structure level in Table I, the traffic ratio of 14 industries in table. Assume that the time series of relevant indicators for 2006-2014 is:

$$X_i = (x_i(1), x_i(2), x_i(3), x_i(4), x_i(5), x_i(6), x_i(7)), i = 0,1,2, \dots, 14.$$

Among, x_0 can indicate the level indicators of the secondary industry, the tertiary industry, and the comprehensive industrial structure, x_1, x_2, \dots, x_{14} is the proportion of investment stocks in various industries in China's OFDI, x_0 and x_i have the same length and are all 1 time sequence.

The grey absolute correlation reflects the degree of similarity between the sequence X_0 and $X_i (i = 1,2, \dots, 14)$. The

higher the similarity between X_0 and X_i , the higher the absolute correlation, and vice versa. make

$$X_i^0 = (x_i(1) - x_i(1), x_i(2) - x_i(1), \dots, x_i(7) - x_i(1)) = (x_i^0(1), x_i^0(2), \dots, x_i^0(7))$$

$$i = 0,1,2, \dots, 14.$$

get $X_0^0, X_1^0, X_2^0, \dots, X_{14}^0$ Is the zeroing image at the beginning of each sequence.

$$|S_i - S_0| = \left| \sum_{k=2}^6 (x_i^0(k) - x_0^0(k)) + \frac{1}{2} (x_i^0(7) - x_0^0(7)) \right|, i = 0,1,2, \dots, 14.$$

$$\varepsilon_{0i} = \frac{1 + |S_0| + |S_i|}{1 + |S_0| + |S_i| + |S_i - S_0|}, i = 0,1,2, \dots, 14.$$

The grey absolute correlation degree ε_{0i} between OFDI industry and industrial structure is obtained.

The grey relative correlation degree reflects the relationship between the change rate of X_0 and $X_i (i = 1,2, \dots, 14)$ relative to the starting point. The more similar the change rate of X_0 and X_i , the higher the relative correlation degree, and the lower the reverse order

$$X_i' = \left(\frac{x_i(1)}{x_i(1)}, \frac{x_i(2)}{x_i(1)}, \dots, \frac{x_i(7)}{x_i(1)} \right) = (x_i(1), x_i(2), \dots, x_i(7)) i = 0,1,2, \dots, 14.,$$

Get the initial value of $X_i (i = 0,1,2, \dots, 14)$. from

$$X_i^0 = (x_i(1) - x_i(1), x_i(2) - x_i(1), \dots, x_i(7) - x_i(1)) = (x_i^0(1), x_i^0(2), \dots, x_i^0(7)),$$

$$i = 0, 1, 2, \dots, 14.$$

The zeros of $X_0^0, X_1^0, X_2^0, \dots, X_{14}^0$ are the starting points of each sequence. adopt

$$|S'_i| = \left| \sum_{k=2}^6 x_i^0(k) + \frac{1}{2} x_i^0(7) \right|, i = 0, 1, 2, \dots, 14.$$

$$|S'_i - S'_0| = \left| \sum_{k=2}^6 (x_i^0(k) - x_0^0(k)) + \frac{1}{2} (x_i^0(7) - x_0^0(7)) \right|, i = 0, 1, 2, \dots, 14.$$

$$\gamma_{0i} = \frac{1 + |S'_0| + |S'_i|}{1 + |S'_0| + |S'_i| + |S'_i - S'_0|}, i = 0, 1, 2, \dots, 14.$$

The grey relative degree of γ_{0i} between OFDI industry and industrial structure is obtained.

The grey comprehensive correlation degree can not only reflect the similarity between sequence X_0 and $X_i (i = 0, 1, 2, \dots, 14)$, but also the relation between the change rate of X_0 and $X_i (i = 0, 1, 2, \dots, 14)$ relative to the starting point. It can reflect the relation degree of sequence comprehensively. Taking $\theta = 0.5$ means equal attention to absolute quantity and rate of change.

$$\rho_{0i} = \theta \epsilon_{0i} - (1 - \theta) \gamma_{0i}, i = 0, 1, 2, \dots, 14.$$

The gray comprehensive correlation degree p_{0i} between the OFDI industry and the industrial structure is obtained, and the gray comprehensive correlation order is discharged according to the comprehensive correlation degree, so as to judge the influence degree of the OFDI industry on the development of domestic industries.

Through the above three calculation steps, we can get the absolute correlation degree, relative correlation degree and comprehensive correlation degree between the industry structure and industrial structure of China's OFDI stock.

According to the comprehensive correlation degree, the top six OFDI industries that affect the secondary industry are leasing and business services, mining, manufacturing, other industries, residential services and other services, transportation, warehousing and postal; the top six OFDI industries that affect the tertiary industry are in turn. It is leasing and business services, mining, residential services and other services, manufacturing, other industries, transportation, warehousing and postal services; the top six OFDI industries affecting the overall industrial structure are leasing and business services, mining, other industries, manufacturing, residential services and other services in turn. Transportation, warehousing and postal services.

TABLE II. Grey correlation between OFDI industry structure and industrial structure in China.

	The secondary industry			Tertiary Industry			Comprehensive industrial structure level		
	Absolute relevance	Relative relevance	Comprehensive relevance	Absolute relevance	Relative relevance	Comprehensive relevance	Absolute relevance	Relative relevance	Comprehensive relevance
Leasing and business services	0.902	0.865	0.884	0.838	0.945	0.892	0.676	0.946	0.811
mining industry	0.757	0.989	0.873	0.716	0.833	0.774	0.612	0.919	0.766
wholesale Retail industry	0.508	0.634	0.571	0.507	0.587	0.547	0.504	0.609	0.557
Financial industry	0.509	0.634	0.570	0.507	0.587	0.546	0.503	0.609	0.557
manufacturing	0.601	0.978	0.789	0.585	0.811	0.698	0.544	0.892	0.718
Construction industry	0.504	0.633	0.568	0.503	0.586	0.545	0.502	0.609	0.555
Transportation, warehousing and postal services	0.548	0.785	0.667	0.541	0.686	0.613	0.521	0.734	0.627
Real estate industry	0.515	0.785	0.651	0.513	0.685	0.599	0.506	0.734	0.621
Electricity, heat, gas and water production and supply	0.508	0.763	0.636	0.507	0.671	0.589	0.503	0.716	0.610
Scientific research and technical services	0.504	0.636	0.570	0.503	0.588	0.546	0.503	0.611	0.556
Agriculture, forestry, animal husbandry and fishery	0.506	0.695	0.601	0.505	0.627	0.566	0.502	0.660	0.581
Information transmission, software and information technology services	0.505	0.649	0.577	0.504	0.597	0.551	0.502	0.622	0.562
Resident services and other services	0.533	0.811	0.672	0.528	0.978	0.753	0.514	0.880	0.697
other industry	0.512	0.942	0.727	0.511	0.868	0.689	0.505	0.936	0.734

C. Result Analysis

From the above empirical analysis, we can see that (1) there is a certain correlation between China's foreign direct investment industry structure and the domestic three industrial structure, but the degree of association between various industries and the three domestic industries is different; (2) in China In the foreign direct investment industry, labor-intensive industries represented by manufacturing and business services and technology-intensive industries characterized by computer service software have a significant impact on China's three industries. In addition, the agricultural and sideline industries and the mining industry are The resource-intensive industries represented will also have a certain impact on China's domestic industrial restructuring, but the impact is less than labor-intensive and technology-intensive industries.

Related industries are leasing and business services, manufacturing, transportation, warehousing and postal, wholesale and retail. Leasing and business services are the most influential industries, which have the largest OFDI stock (mainly investment holding). As producer services, domestic enterprises cannot match developed countries' enterprises in business management, law, consultation, market channels, marketing networks and so on.

China's enterprises continue to accelerate the pace of "going out" to achieve the goal of stabilizing the European and American markets and opening up new markets. OFDI through investment holding not only rapidly acquires much-needed business services, innovates sales methods and channels, but also indirectly promotes the development of domestic leasing and business services from its added value. There are obvious progress in terms of growth rate and employment situation. China is a big manufacturing country. Through OFDI, China has realized the transfer of domestic excess capacity and avoided trade barriers, and promoted the transformation and upgrading of related industries. Transportation, warehousing, postal, wholesale and retail industries as supporting industries, effectively guaranteed the smooth sale of products, to a certain extent, promoted the optimization of domestic industrial structure.

The correlation between mining industry and domestic industrial structure is second. Natural resources have always been a hot area of China's OFDI. State-owned enterprises, such as PetroChina, Sinopec, China Aluminum, Baosteel, Angang and Minmetals, have acquired natural resources such as oil, natural gas and iron ore through cash and equity. The amount of mergers and acquisitions ranges from hundreds of millions of dollars to tens of billions of dollars. The targets of mergers and acquisitions are all over the world. In five continents, especially during the financial crisis, China's state-owned resource-based enterprises have carried out more than half of the world's cross-border M&A of resource-based enterprises. These investments have effectively protected the supply of domestic energy resources and promoted the upgrading and upgrading of related industries.

In order to maintain the leading edge in technology, developed countries often use various excuses to scrutinize the

foreign capital mergers and acquisitions involving high-tech cooperation and transfer, which leads to a small OFDI in China's information transmission, software and information technology services, scientific research and technology services, and a small number of high-tech enterprises directly merged. Moreover, the transmission cycle of technological progress in China is long, so it needs a process to exert the reverse spillover effect of technology, and the effect of industrial structure optimization is only temporarily not obvious. Acquiring advanced technology through OFDI, strengthening digestion, absorption and re-innovation, and improving the ability of independent innovation and collaborative innovation are important strategic measures for building an innovative country, which need to be further strengthened.

IV. SUGGESTIONS AND COUNTERMEASURES

International direct investment will flourish, China's OFDI will enter a high-speed development stage, capital inflow and outflow will become increasingly balanced, in order to make OFDI better to enhance domestic welfare, we need to study and formulate OFDI strategic planning from the national level. The planning is a comprehensive system of coordination between regional planning and industrial planning. According to the factor endowment advantages of different regions, countries and regions and the stage of economic and social development, OFDI strategic planning is formulated to define the regional positioning, regional investment objectives and industrial investment objectives and supporting measures. At the same time, OFDI strategic planning needs to reflect the multi-faceted promotion function, that is, in the long-term development process of OFDI, it is conducive to the mutual promotion of reform and opening up, the mutual promotion of international and domestic market development, and the mutual promotion of economic strength, political and diplomatic strength. Taking OFDI as an opportunity to deepen the reform of domestic economic system, we should focus on breaking through the financial reform and the reform of state-owned enterprises. At the same time, we should strengthen the development of economic diplomacy and human diplomacy, and form a benign interaction between OFDI and national diplomatic strategy.

Enterprises are the main body to carry out OFDI, whether large state-owned enterprises, small and medium-sized private enterprises, no matter where the region and industry, in order to make profits in the competitive international market, we need to enhance their strength in many ways. The first is to speed up the establishment of modern enterprise system, to achieve clear property rights, clear rights and responsibilities, scientific decision-making, incentive mechanism and supervision and restraint mechanism to promote each other, so that enterprises really become the main body of the market economy. Secondly, OFDI should attach importance to talents. OFDI needs a large number of high-quality international talents. It is necessary to establish an effective incentive mechanism, introduce excellent talents and build a platform for them to display their talents. Thirdly, we should strengthen

technological innovation, perfect innovation incentive mechanism, increase investment in scientific research, improve the ability of independent innovation, actively establish contacts with universities and research institutions at home and abroad, carry out various forms of joint research, development, cooperation and technology transfer, so as to enhance the technological strength of enterprises. Finally, a strong enterprise should pay attention to cultivating its brand, show its image, reputation and comprehensive quality through the brand, and gradually become an international brand, so as to gain international competitive advantage.

The first is to promote the process of convertibility of overseas investment. Foreign investment can be convertible first, and then OFDI convertible. The banks will examine the specific business according to different treatment. The second is to gradually relax the foreign exchange control over enterprises' international operations, relax the restrictions on the qualifications of domestic parent companies to lend money to overseas subsidiaries, grant qualified multinational enterprises the necessary overseas financing rights, and allow them to open up international financing channels by issuing stocks and bonds, establishing funds, etc. The third is to establish the OFDI industry fund, adopt diversified equity design, combine the state, banks, enterprises, professional investment institutions, implement specialized investment, carry out equity mergers and acquisitions, focusing on modern services and strategic emerging industries. Fourthly, we should enrich the main body of export credit insurance and establish commercial export credit insurance companies, which are different from policy insurance companies in terms of business scope and insurance varieties, so as to provide more abundant insurance services for diversified enterprises.

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